BOUNDARY LAYER TRIP PERFORMANCE TEST ON A 7-DEG CONE MODEL AT MACH NUMBER 8

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Calspan Field Services, Inc.

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This study was performed to obtain additional knowledge of the physical characteristics and occurrences within a tripped boundary layer as well as determining suitable techniques for the measurement of these characteristics. A sharp, 7-deg half-angle cone model was tested in Mach 8 flow conditions at free-stream unit Reynolds numbers of 1.3- and 2.6-million per foot at zero angle of attack. Boundary layer surveys (pitot and total temperature), coax heat-gage, and model pressure data were acquired for comparison of a variety of boundary layer trip geometries.

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NOMENCLATURE

ALPHA, α	Angle of attack, deg
ALPHA SECTOR	Pitch angle of the tunnel sector, positive nose up, deg
CFX, C_{f_x}	Skin friction coefficient, [TAUX/Q]
CLD	Survey station location, inches
CONFIG CONFIGURATION	Model configuration designation
C.R.	Center of rotation, axial station along the tunnel centerline about which the model rotates, inches
DATA TYPE	Code indicating nature of data tabulated: SURFACE HEAT TRANSFER - Cold wall model surface heat-transfer measurements "2" - Model surface pressure measurements "4" - Mean boundary-layer profile measurements using pitot pressure and total temperature probes "6" - Total temperature probe calibration data
DEL, δ	Boundary-layer total thickness, in.
DEL*	Boundary-layer displacement thickness, in.
DEL**	Boundary-layer momentum thickness, in.
DEW, DEW PT.	Free-stream flow frost point, °F
DITTD	Enthalpy difference at boundary-layer thickness, DEL, ITTD-ITWL, Btu/lbm
DITTL	Local enthalpy difference, ITTL-ITWL, Btu/lbm
DRUCK 2	Backup pitot probe measurement, psia
ERMS	Anemometer output rms voltage for the last point survey, mv rms
ERMSR	Ratio of anemometer output (ERMS to ERMS of last loop of output)

ETA — Effective total-temperature probe recovery factor

For calibration data: ETA=(TTLU-T)/(TT-T)

For survey data: $ETA = \sum_{i=1}^{i} A_i (\sqrt{RETD})^i$

where the values of A_i were determined for each thermocouple probe. (See Section 3.3.4 for coefficient values used for this test).

G — Preston tube data reduction parameter

H(TT) — Heat-transfer coefficient based on TT, QDOT/(TT-TW), Btu/ft^2-sec-°R

ITT — Enthalpy based on TT, Btu/lbm

ITTD — Enthalpy based on TTD, Btu/lbm

ITTL — Enthalpy based on TTL, Btu/lbm

ITW — Enthalpy based on TW, Btu/lbm

ITWL — Enthalpy based on TWL, Btu/lbm

k — Height or thickness of boundary layer trip above model surface, inches

K — Coefficients defined by the pressure stabilization routine for pitot pressures; the equilibrium pressure routine was applied if $0.01 < K < 3$

LOOP — Data point number

LRE — Local unit Reynolds number, in.$^{-1}$

LRED — Unit Reynolds number at the boundary-layer thickness, DEL, in.$^{-1}$

LRET — Local "normal shock" unit Reynolds number (based on MUTTL), in.$^{-1}$

LRETA — "Normal shock" unit Reynolds number at ZA (based on MUTTL), in.$^{-1}$

LRETD — "Normal shock" unit Reynolds number at boundary-layer thickness, DEL (based on MUTTD), in.$^{-1}$

M, MACH, M_∞ — Free-stream Mach number

MA — Mach number interpolated to the anemometer location

MD	Local Mach number at boundary-layer thickness, DEL, in.$^{-1}$
ME	Mach number at last point in the survey
ML	Local Mach number
MODEL ROLL, ROLL	Roll angle, deg
MT	Equivalent Mach number corresponding to pitot pressure ratio; compressibility parameter
MU	Dynamic viscosity based on T, lbf-sec/ft^2
MUTD	Dynamic viscosity based on TD, lbf-sec/ft^2
MUTL	Dynamic viscosity based on TL, lbf-sec/ft^2
MUTT	Dynamic viscosity based on TT, lbf-sec/ft^2
MUTTD	Dynamic viscosity based on TTD, lbf-sec/ft^2
MUTTL	Dynamic viscosity based on TTL, lbf-sec/ft^2
P	Free-stream static pressure, psia
PHI, ϕ	Roll angle, deg
POINT	Data point number
PP	Probe pitot pressure, psia
PPD	Pitot pressure at boundary-layer thickness, DEL, psia
PPE	Pitot pressure the last point in the survey, psia
PPF	Final transducer pressure measurement for the pitot probe, psia
PPR	Standard deviation of the pressure-time history curve fit used to compute the equilibrium pressure for the pitot probe; value defined as zero if equilibrium pressure evaluation routine was not used, psi
PPRES	Preston tube pressure, psia
PP1	First transducer pressure measurement for the pitot probe, psia
PT	Tunnel stilling chamber pressure, psia
PTP	Transformed Preston tube compressibility parameter

PT2	Free-stream total pressure downstream of a normal shock wave, psia
PW	Model surface pressure, psia
PWL	Model wall static pressure used for boundary-layer survey, psia
Q	Free-stream dynamic pressure, psia
QDOT, $\dot{q}$	Heat-transfer rate, Btu/ft^2-sec
RE,RE/IN.	Free-stream unit Reynolds number, in.$^{-1}$
RE/FT	Free-stream unit Reynolds number, ft^{-1}
RETD	Local "normal shock" Reynolds number based on total temperature probe reference dimension and viscosity of MUTTL
RHO	Free-stream density, lbm/ft^3
RHOD	Density at boundary-layer thickness, DEL, lbm/ft^3
RHOL	Local density, lbm/ft^3
RHOUD	(RHOD) $\times$ (UD), lbm/sec-ft^2
RN, RADIUS	Model nose radius, in.
RUN	Data set identification number
RT	Calibration parameter for Preston tube reduction
S	Curvilinear surface distance from model stagnation point, in.
SD PW	Model wall pressure standard deviation
SD TW	Model wall temperature standard deviation
ST(TT)	Stanton number based on stilling chamber temperature (TT), $$ST(TT) = \frac{QDOT}{(RHO)(V)(ITT-ITW)}$$
STC(TT)	Corrected Stanton number (see Section 3.3.2 of text)
T	Free-stream static temperature, °R
t	Thickness of trip band, in.

TAP	Pressure orifice identification number
TAUX, τ_x	Wall shear stress; shear magnitude in lateral direction, lb/ft^2
T/C	Thermocouple identification number
TD	Static temperature at boundary-layer thickness, °R
TDRK	Temperature of Druck transducer, °F
THETA, θ	Peripheral angle on the model measured from ray on model top, positive clockwise when looking upstream, deg
TL	Local static temperature, °R
TLAG	Estimated lag time (time required for pitot pressure to stabilize within 1 percent of equilibrium value, referenced to time when data record began), sec
TREC	Data record length, sec
TRIP	Indicate for type/size trip used on specific data runs
TT	Tunnel stilling chamber temperature, °R
TTA	Total temperature interpolated to the anemometer location, °R
TTD	Total temperature at the boundary layer thickness, DEL, °R
TTE	Total temperature at last point in the survey, °R
TTL	Local total temperature, °R
TTLU	Uncorrected (measured) probe total temperature, interpolated at ZP, °R
TTTU,TTUT	Uncorrected (measured) probe recovery temperature in free stream, °R
TW	Coax gage surface temperature, °R
TWL	Model wall temperature used for boundary-layer survey, °R
UD	Local velocity component parallel to model surface at boundary-layer thickness, DEL, ft/sec
UE	Local velocity component parallel to model surface at last point in the survey, ft/sec

UL	Local velocity component parallel to model surface, ft/sec
V	Free-stream velocity, ft/sec
w	Distance between successive rows of trip elements on multiple row trip rings, inches
X	Axial location measured from virtual apex of 7-deg cone model, in.
x	Axial distance measured from trip location (x/k), in.
XSTA	Survey station, along x-axis, inches
ZA	Anemometer probe height, distance to probe centerline along normal to model surface, in.
ZP	Pitot-pressure probe height, distance to probe centerline along normal to model surface, in.
ZT	Total-temperature probe height, distance to probe centerline along normal to model surface, in.
θ, θ_r	Angle between successive teeth or balls on the trips, degs (360/# of teeth)
θ_t	Angle across a tooth of the serrated trips, deg (for these trips, θ_t = 90 degs)

1.0 INTRODUCTION

The work reported herein was performed by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC) under Program Element 65807F, Control Number 9R02, at the request of AEDC Directorate of Technology (DOT). The AEDC/DOT project manager was R. H. Nichols. The results were obtained by Calspan Field Services, Inc./AEDC Division, operating contractor for the Aerospace Flight Dynamics testing effort at the AEDC, AFSC, Arnold Air Force Station, Tennesse. The test was performed in the von Karman Gas Dynamics Facility (VKF), in the Hypersonic Wind Tunnel (B) on September 1 and September 6, 1983, under the AEDC Project Number C868VA (Calspan Project Number V--A-2S).

The Boundary Layer Trip Performance Study was performed to provide some of the experimental data in support of AEDC Research Program DA12VW (V32C-AD), Aerodynamic Testing Techniques, Work Phase II, Boundary Layer Simulation Criteria.

The objectives of the study were: (1) to characterize the disturbance produced by a typical trip on an attached laminar boundary layer in a supersonic stream; (2) to define the distance aft of the trip location before the boundary layer profile reverts to the classic turbulent flow profile; (3) to locate the end of fully laminar flow and the onset of the turbulent boundary layer flow, and to define the shift in these locations caused by changing trip geometry or size; and (4) to determine the suitability of a variety of different techniques to measure these objectives.

A sharp nose seven-degree cone model was tested at Mach number 8 flow conditions at free-stream unit Reynolds numbers of 1.3- and 2.6-million per foot and at zero angle of attack.

A summary of the test data transmitted to the sponsor and user is presented in Table 1. Inquiries to obtain copies of the test data should be directed to AEDC/DOT, Arnold AFS, TN 37388. A microfilm record has been retained by AEDC/VKF.

2.0 APPARATUS

2.1 TEST FACILITY

Tunnel B (Fig. 1) is a closed circuit hypersonic wind tunnel with a 50-in.-diam test section. Two axisymmetric contoured nozzles are available to provide Mach numbers of 6 and 8 and the tunnel may be operated continuously over a range of pressure levels from 20 to 300 psia at Mach number 6, and 50 to 900 psia at Mach number 8, with air supplied by the VKF main compressor plant. Stagnation temperatures sufficient to avoid air liquefaction in the test section (up to 1350°R) are obtained through the use of a natural gas fired combustion heater. The entire tunnel (throat, nozzle, test section, and diffuser) is cooled by integral, external water jackets. The tunnel is equipped with a model injection system, which allows removal of the model from the test section while the tunnel remains in operation. A description of the tunnel may be found in the Test Facilities Handbook (Ref. 1).

2.2 TEST ARTICLE

A sharp-nosed configuration of the Lubard model (fabricated several years ago at AEDC) was used for this investigation. The model was a 7-deg half-angle cone with a virtual length of 40.0 in. and 9.823-in. base diameter featuring the basic sharp nose (RN = 0.0015 in.).

The model was instrumented with pressure orifices and coaxial surface thermocouple gages. Table 2 lists the instrumentation locations and indicates that the top centerline (θ = 0) of the model was the main ray of pressure instrumentation and the bottom centerline (θ = 180 deg) was the only ray instrumented with coax gages. Pressure orifices were also installed on the θ = 180- and 270-deg rays at three additional axial stations. Two Preston tubes were mounted 1.5 inches forward of the model base, one at θ = +135 deg and one at θ = +225 deg. These tubes had an outside diameter of 0.022 in. and an inside diameter of 0.010 in.

A sketch of the model geometry and gage locations is given in Fig. 2. A model installation photograph is shown in Fig. 3.

Boundary layer trips of various geometries were mounted at model station 12 (x = 12 axial inches measured from the model nosetip) to investigate the effect on the turbulent boundary layer conditions on the model. Six different trip configurations were tested, including single and multiple rows of spherical balls, serrated bands, and a basic ring. Table 3 gives trip configurations and respective geometries. A photograph and sketch of the various trips are shown in Figs. 4 and 5, respectively.

2.3 FLOW-FIELD SURVEY MECHANISM

Surveys of the flow field were made using a retractable survey system (X-Z Survey Mechanism) designed and fabricated at AEDC. This mechanism makes it possible to change survey probes while the tunnel remains in operation. The mechanism is housed in an air lock immediately above a port in the top of the Tunnel B test section. Access to the test section is through a 40-in.-long by 4-in.-wide opening which can be sealed by a pneumatically operated door when the mechanism is retracted. Separate drive motors are provided to (1) insert the mechanism into the test section or retract it into the housing, (2) position the mechanism at any desired axial station over a range of 35 in., and (3) survey a flow field of approximately 10-in. depth. A pneumatically operated shield was provided to protect the probes during injection and retraction through the tunnel boundary layer, during changes in tunnel conditions, and at times when the probes were not in use. A photograph of the mechanism is shown in Fig. 6.

2.4 FLOW-FIELD PROBES

The pitot pressure probe was made from an 0.010-in. O.D. (0.005 I.D.) tube, as shown in Fig. 7a. The tube section adjacent to the orifice was bent to align the probe parallel to the model surface for the surveys.

The unshielded total temperature probe was fabricated from a length of sheathed thermocouple wire (0.020-in. O.D.) with two 0.004-in. diameter wires. The wires were bared for a length of about 0.015 in. and a thermocouple junction of approximately 0.005-in.-diam was made. Details of this probe are shown in Fig. 7b.

The hot-film anemometer probe (Fig. 7c), designed and fabricated by AEDC, consisted of an 0.002-in. diameter glass rod ground to a slender double wedge at the leading edge. A thin platinum film was then deposited (painted) along the leading edge. Two strips of gold painted along the rod served to connect the film to wire leads from the anemometer instrumentation.

A sketch of the survey probe rake used during the test is given in Fig. 8.

2.5 TEST INSTRUMENTATION

2.5.1 Standard Instrumentation

The measuring devices, recording devices, and calibration methods for all parameters measured during this test, with the exception of the basic anemometer instrumentation, are listed in Table 4 along with the estimated measurement uncertainties. The uncertainties in the stilling chamber properties, as itemized in this table, were used in conjunction with previously established nozzle Mach number calibrations as the basis for defining the uncertainties in the test section properties. Also identified in Table 4 are the standard wind tunnel instruments and measuring techniques used to define test parameters such as the model attitude, the model surface pressure, probe positions, and probe measurements. Additional special instrumentation used in support of this test effort is discussed in the following subsections.

2.5.2 Model Surface Instrumentation

Thirty-two coaxial surface thermocouple gages (1/8-in. diam) were used to measure the model surface heating rates and surface temperatures. The coax gage consists of an electrically insulated Chromel® center closed in a cylindrical Constantan® sleeve. After assembly and installation in the model, the gage materials were blended together with a file creating thermal and electrical contact in a thin layer at the surface of the gage.

Twenty-four surface and base pressure taps were located along the zero-deg ray of the model with the exception of four taps which were located on the 180-deg ray and three taps on the 270-deg ray, to aid in aerodynamic alignment. These taps, having approximate outside diameters of 0.093-in., were connected by tubing to the Tunnel B Standard Pressure System.

2.5.3 Hot-Film Anemometry

Flow fluctuation measurements were made using hot-film anemometry techniques. Constant-current hot-film anemometer instrumentation with auxiliary electronic equipment was furnished by AEDC. The anemometer current control (Philco-Ford Model ADP-13) which supplies the heating current to the sensor is capable of maintaining the current at any one of 15 preset levels individually selected using push-button switches. The anemometer amplifier (Philco-Ford Model ADP-12) which amplifies the film-response signal contains the circuits required to compensate the signal electronically for thermal lag which is a characteristic of the finite heat capacity of the film. A square-wave generator (Shapiro/Edwards Model G-50) was used in determining the time constant of the sensor whenever required. The sensor heating current and mean voltage were fed to autoranging digital voltmeters for a visual display of these parameters and to a Bell and Howell model VR3700B magnetic tape machine for recording. The sensor response a-c voltage was fed to an oscilloscope for visual display of the raw signal and to a wave analyzer (Hewlett-Packard Model 853B/8552B) for visual display of the spectra of the fluctuating signal and was recorded on magnetic tape for subsequent analysis.

The analog response signals from the hot-film anemometer were recorded using the Bell and Howell Model VR3700B magnetic tape machine in the FM mode. Each channel was calibrated and adjusted to have a signal-to-noise ratio of 35 db for a 1.000 volt rms output. The tape machine frequency response was +1 to -3 db over a frequency range of dc to 500 kHz. In the present calibration, a sine wave generator was used to check each channel at several discrete frequencies, using an rms-voltmeter which is periodically checked on 1, 10, and 100 volt ranges. Magnetic tape recordings were made at a tape speed of 7.5, 60, or 120 in./sec.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS AND PROCEDURES

A summary of the nominal test conditions is given below.

M	PT ,psia	TT, °R	Q, psia	P, psia	RE/FT x 10^{-6}
8.00	300	1350	1.38	0.031	1.3
↓	600	1350	2.75	0.061	2.6

A test summary noting all configurations tested and variables for each is presented in Table 5.

In the continuous-flow wind Tunnel B, the model is mounted on a sting support mechanism in an installation tank directly underneath the tunnel test section. The tank is separated from the tunnel by a pair of fairing doors and a safety door. When closed, the fairing doors, except for a slot for the pitch sector, cover the opening to the tank and the safety door seals the tunnel from the tank area. After the model is prepared for a data run, the personnel access door to the installation tank is closed, the tank is vented to the tunnel flow, the safety and fairing doors are opened, the model is injected into the airstream, and the fairing doors are closed. After the data are obtained, the model is retracted into the tank and the sequence is reversed with the tank being vented to atmosphere to allow access to the model in preparation for the next run. The sequence is repeated for each configuration change.

Probes required for flow-field measurements are rake-mounted on the X-Z Survey Mechanism and are deployed for measurements by the following sequence of operations: The air lock is closed, secured over the mechanism and evacuated, and the access door to the tunnel test section is opened. The various drive systems are used to inject the probes into the test section and position the probes at a designated survey station along the length of the model, the shield protecting the probes is raised exposing them to the flow, and the flow field is traversed in the direction normal to the model surface to the probe height (or heights) selected for measurements. When the traverse has been concluded, the shield is closed over the probes and the mechanism is repositioned along the model. When the surveys are completed or when a probe is to be replaced, the X-Z Mechanism is retracted from the flow and the access door is closed. The air lock is then opened for probe work.

Positioning of the probe at a desired location (in terms of X) on the model was accomplished using the x-readout of the data acquisition system after previously aligning the x-readout with a known location on the model. Survey stations were chosen so that the surveys would be conducted at multiples of the trip height (x/k) downstream of the trip location (X = 12-in.). The 36-deg serrated band trip seated slightly forward of the intended position so that the actual position was X = 11.56-in. The survey at x/k = 10 was adjusted accordingly, but the aft survey was conducted at X = 25.5, yielding an x/k = 112 instead of 108. Model survey stations for each run are listed in Table 5.

The survey probe height relative to the model is monitored using a high-resolution closed-circuit television (CCTV) system. The camera is fitted with a telescopic lens system which gives a magnification factor of 20 (from tunnel centerline to monitor picture). The probe and model are back-lighted using the collimated light beam of the Tunnel B shadowgraph system which is aligned with respect to the model just prior to testing. Calibration of the system is made using a wire of 0.010-in. diameter positioned at the test section centerline. Subsequent measurements are made on the face of the monitor picture tube using scales prepared from the calibration images. The field of view is approximately 0.3 in. (axially) by 0.2 in. (vertically) and a spacing of 0.001 in. is easily discernible. The camera is isolated from tunnel vibrations by mounting it with the Tunnel B optics system, which has a foundation separate from that of the tunnel.

3.2 DATA ACQUISITION

Basic data acquisition procedures can be divided into four major data types: overhead probe survey data, surface heat-transfer data, model surface pressure and temperature measurements, and hot-film anemometry data.

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3.2.1 Flow-Field Survey Data

Mean-flow boundary-layer profiles extended from a height of 0.005 in. above the model surface to a height greater than the boundary-layer thickness. A profile typically consisted of 35 to 40 data points (heights). The probe direction of travel was normal to the surface. The small size of the pitot probe adjacent to the orifice was characterized by time delays for the stabilization of pressure within the probe tubing between orifice and transducer. Indeed, the long delay experienced with the pitot probe positioned near the model surface made it impractical to wait for the pressure to stabilize at every survey point. As an alternative, a pressure-time history of the probe response was determined at each survey point. In subsequent data reduction (Section 3.3), the pressure-time history was interpreted as describing an exponential probe-response curve that was extrapolated to define the final or stabilized pressure level at the probe location. The following sequence was used to acquire data for this pressure prediction scheme: With the pitot probe positioned at a specified height above the model surface, the data acquisition was begun following a prescribed time delay (generally from 5 to 30 sec), and the pitot pressure was measured 40 times at equally-spaced time intervals (in the range from 0.4 to 1.5 sec). Each sequence was considered independently so that the prescribed time delay could be varied from one sequence (that is from one probe position) to the next.

The flow-field surveys were generally obtained only after the model had reached equilibrium temperature, and the model was oriented at various roll angles (depending on the trip) to avoid interference of the surface instrumentation with the flow field being surveyed.

3.2.2 Surface Heat Transfer Data

Surface heat transfer data were obtained using 32 coaxial thermocouple gages. The model was injected into the tunnel test section at a fixed attitude (ALPHA = zero). The data were recorded continuously for a period of approximately five seconds beginning one second after the model encountered tunnel centerline. The model was then retracted into the test section tank and cooled with high pressure air.

Surface pressure and temperature distributions on the model were obtained to supplement the boundary layer profile data.

3.2.3 Hot-Film Anemometry

The hot-film anemometer data were continuous-traverse surveys of the boundary-layer to map the response of the hot-film anemometer as a function of distance normal to the surface. These data were acquired by operating the hot-film under a single heating current. The probe was translated in a continuous manner from near the model surface outward to a distance of approximately 2δ. These data were recorded as analog plots of the hot-film response (rms of the d-c voltage component) versus probe height normal to the model surface. The plot was used primarily for the purpose of determining the station(s) in the boundary-layer profile where the hot-film output had a (local) maximum level. During each traverse, the hot-wire response was also recorded on magnetic tape, at a tape transport speed of 7.5 in./sec.

The various types of data obtained during the testing are summarized in Table 5.

3.2.4 Probe Calibration

A calibration of the recovery factor of the total-temperature probe as a function of local Reynolds number was made in the free-stream flow of the tunnel test section, simultaneously with that of the hot-film probes. The local total temperature for the probes in free-stream flow is assumed to be equal to the measured stilling chamber temperature, TT. The total-temperature probe used in the present testing was found to have a recovery factor that was independent of unit Reynolds number over the range covered by the calibration.

3.3 DATA REDUCTION

3.3.1 Flow-Field Surveys (Data Type 4)

The mean flow-field data (DATA TYPE 4) reduction included calculation of the local Mach number and other local flow parameters, determination of the height of each probe relative to the model surface, correction of the total-temperature probe using an appropriate recovery factor, definition of the boundary layer total thickness, and evaluation of the displacement and momentum thickness. These reduction procedures will now be outlined.

The local Mach number in the flow field around the model was determined using the measured pitot pressure (PP) and the local model static pressure (PWL) with the Rayleigh pitot formula.

The height of each probe above the model surface, in the normal direction, was calculated for each point in a given flow-field survey taking into consideration the following parameters: the initial normal distance scaled from the high-resolution CCTV screen image, the initial deflection of the pitot probe, the distance traversed in the normal direction from the initial position employing the survey probe drive, the lateral displacement of the probe from the vertical plane of the survey, and the local radius of the model at the survey station.

The height of the pitot pressure probe above the model surface (ZP) was used as the reference for all probes because the pitot probe was located in the survey plane of the probe drive mechanism. The total-temperature probe recovery temperature measurements (TTTU) were used to interpolate (three-point) a value (TTLU) corresponding to each height of the pitot probe. Correction of the interpolated recovery temperature using the probe calibration data was achieved by iteration on the local Reynolds number beginning with the value calculated using the recovery temperature (TTLU) to determine an initial value for the local dynamic viscosity (MUTTL). The iteration was continued until successive values of the "corrected" total temperature differed by no more than 0.1 deg R. For those surveys wherein the pitot probe was positioned below the total-temperature probe (closer to the model surface), the corrected total temperature at the corresponding pitot probe heights was determined from a second-order curve fit using three points, namely: the model surface temperature (TWL) and the corrected total temperature at the first two probe heights where it was available.

The total thickness of the model boundary layer in any given profile was inferred from the profile of the total-temperature probe recovery temperature (TTLU). Recovery temperatures measured above the edge of the boundary layer (in the shock layer) remained constant or essentially independent of the probe height. There was generally a very distinct "overshoot" in the recovery temperature profile immediately before the onset of the constant portion of the profile. The height at which this constant portion of the profile began was defined as the edge of the boundary layer and the corresponding distance normal to the model surface was defined as the boundary-layer total thickness (DEL). Displacement and momentum thicknesses were determined by integration accounting for the model cone angle and local radius of curvature. Probe/model interference was noted for some of the data points near the model surface; these points were omitted from the integrations.

In order to optimize data acquisition time and improve the reliability of pitot pressure readings, an equilibrium pressure stabilization routine was used. The routine requires as an input the time-history of the pressure readings from a transducer. This routine then models the time-history as an exponential decay with a step input and evaluates the final equilibrium value. Reference 2 gives a further description of the equilibrium pressure stabilization routine. In many cases the pressures are at equilibrium throughout the data record (essentially constant pressure), and the pressures are simply defined as the average value of the recorded pressures.

The rms of the hot-film response voltage (a-c component) obtained using a single heating current in conjunction with the mean flow-field profile surveys is included (ERMS) among the survey parameters tabulated under the designation "DATA TYPE 4". Pressure and temperature distributions were also measured during mean flow-field surveys (DATA TYPE 4). These measurements were made each time that probe data were acquired and the 35 to 40 values for each pressure or temperature were averaged. The averaged values and their respective standard deviations are included in the tabulations of DATA TYPE 4. A sample tabulation of the flow field survey data (Type 4) is given in Appendix III, Sample 1.

3.3.2 Surface Heat Transfer Data

Heat-flux rate, calculated from the response of the coaxial thermocouple gage, is further used to determine the heat transfer coefficient, H(TT), and the Stanton number, ST(TT). The Stanton number for each gage was shifted by as much as twenty percent, based on theoretical variations of Stanton number versus model length. The wall temperature, TW, is additionally determined and these values are all tabulated under the designation "Surface Heat Transfer". A sample tabulation of the Surface Heat Transfer Data is given in Appendix III, Sample 2.

3.3.3 Model Surface Measurements (Data Type 2)

Model surface pressure and temperature distributions generally were obtained when the survey probe mechanism was located so as not to interfere with the measurements. These data are tabulated under the designation "DATA TYPE 2".

The local model surface pressure, PWL, used in the flow-field calculations was determined using a fairing of the measured pressure distributions (selected runs of DATA TYPE 2). The static pressure was assumed to be constant across the boundary layer and shock layer and equal to the local model surface pressure at each survey station.

The local model surface temperature, TWL, was determined for each survey from the measured surface temperature data in the vicinity of the survey station, using linear interpolation.

A sample tabulation of the Type 2 Data is given in Appendix III, Sample 3.

3.3.4 Total Temperature Probe Calibration (Data Type 6)

The recovery factor ETA used in reducing the survey data is defined as a function of the local Reynolds number based on probe diameter. The coefficients used for data reduction were:

Runs 1018 → 1033: $A_o = 0.94$, $A_i = -0.0019$

Runs 1047 → 1056: $A_o = 0.949$, $A_i = -0.0333$

Free-stream tunnel conditions that are applicable to total-temperature probe calibration are tabulated under the designation "DATA TYPE 6".

A sample tabulation of the total temperature calibration (DATA TYPE 6) is given in Appendix III, Sample 4.

3.4 UNCERTAINTY OF MEASUREMENTS

In general, instrumentation calibration and data uncertainty estimates were made using methods recognized by the National Bureau of Standards (NBS) (Ref. 3). Measurement uncertainty is a combination of bias and precision errors defined as:

$$U = \pm(B + t_{95}S)$$

where B is the bias limit, S is the sample standard deviation, and t_{95} is the 95th-percentile point for the two-tailed Student's "t" distribution (95-percent confidence interval), which for sample sizes greater than 30 is equal to 2.

Estimates of the measured data maximum uncertainties for this test are given in Table 4a. Propagation of the bias and precision errors of measured data through the calculated data was made in accordance with Ref. 3 and the results are given in Table 4b.

4.0 DATA PACKAGE PRESENTATION

The data package consists of two volumes, containing tabulated and plotted data, as well as a nomenclature list, and a detailed run schedule. Appendix III contains examples of the data presented in the data package.

REFERENCES

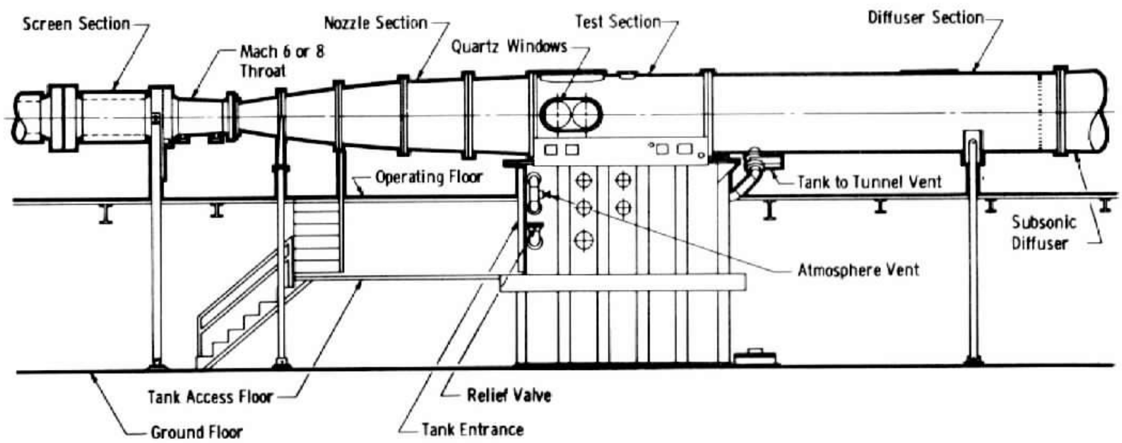
1. Test Facilities Handbook (Eleventh Edition). "von Karman Gas Dynamics Facility, Vol. 3." Arnold Engineering Development Center, April 1981.

2. Brown, David L. "Predicting Equilibrium Pressures from Transient Pressure Data," Aerospace Research Laboratories ARL 65-7, January 1965.

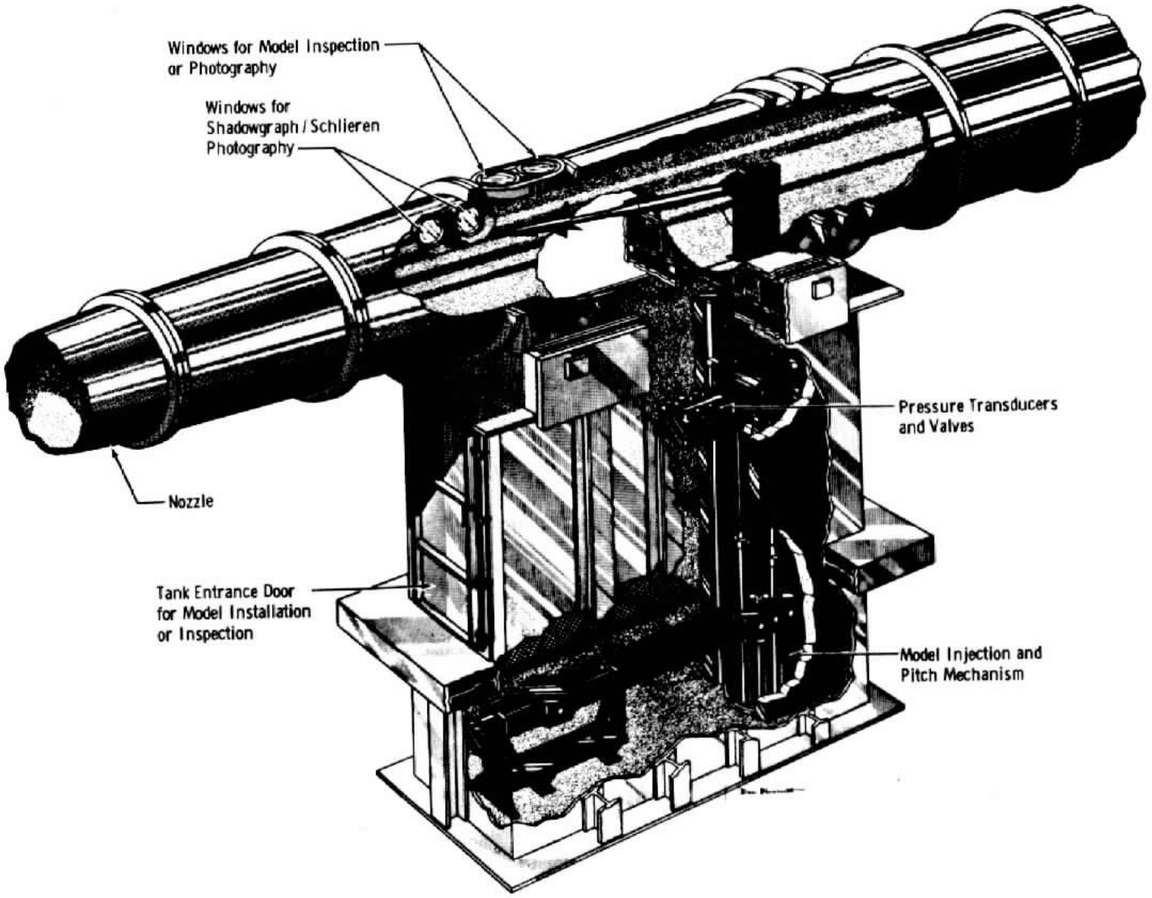
3. Abernethy, R. B., et. al., and Thompson, J. W. "Handbook Uncertainty in Gas Turbine Measurements," AEDC-TR-73-5 (AD 755356), February 1973.

APPENDIX I

ILLUSTRATIONS



a. Tunnel assembly



b. Tunnel test section
Figure 1. Tunnel B.

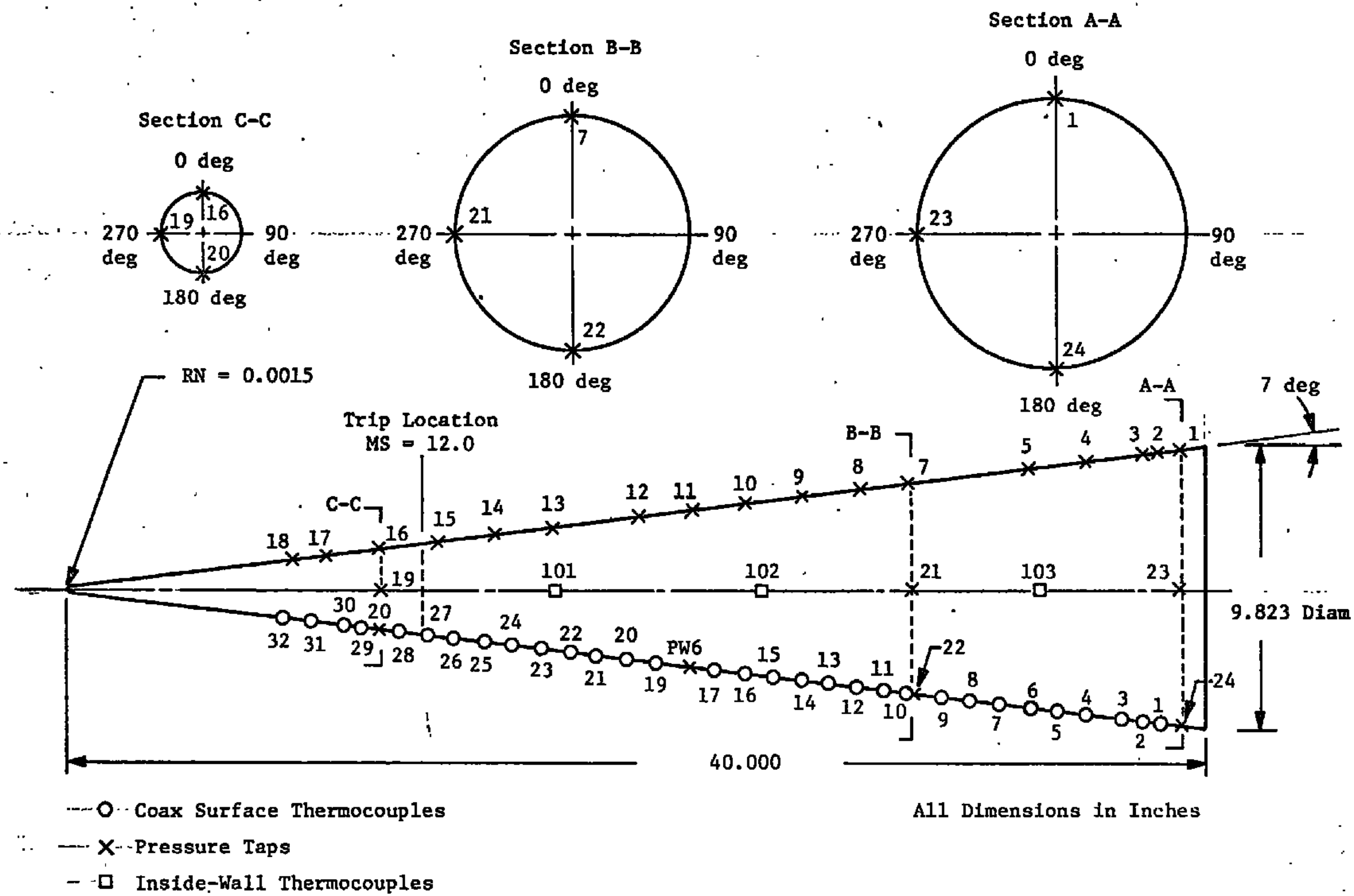


Fig. 2 Model Geometry and Gage Locations

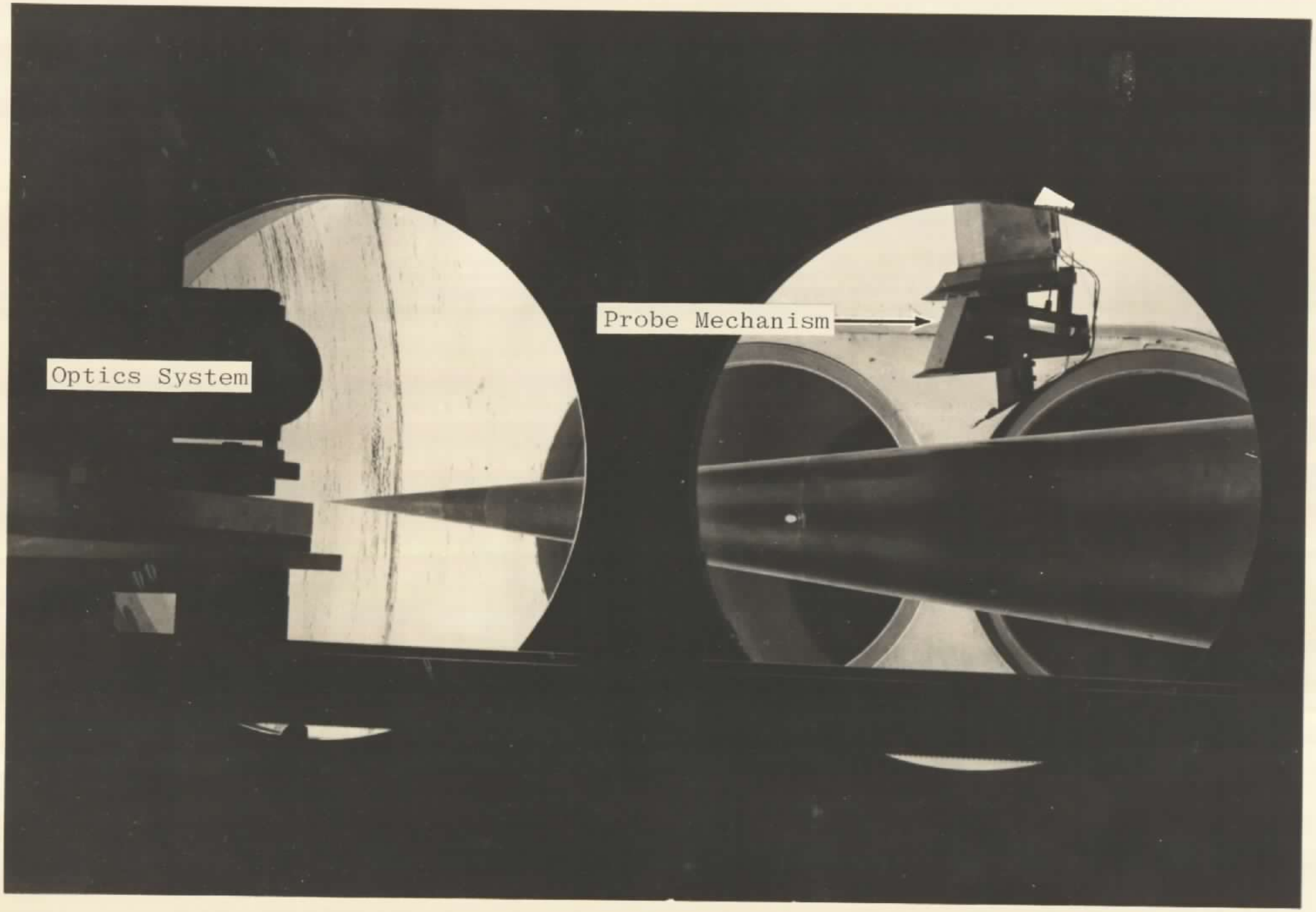


Fig. 3 Test Installation

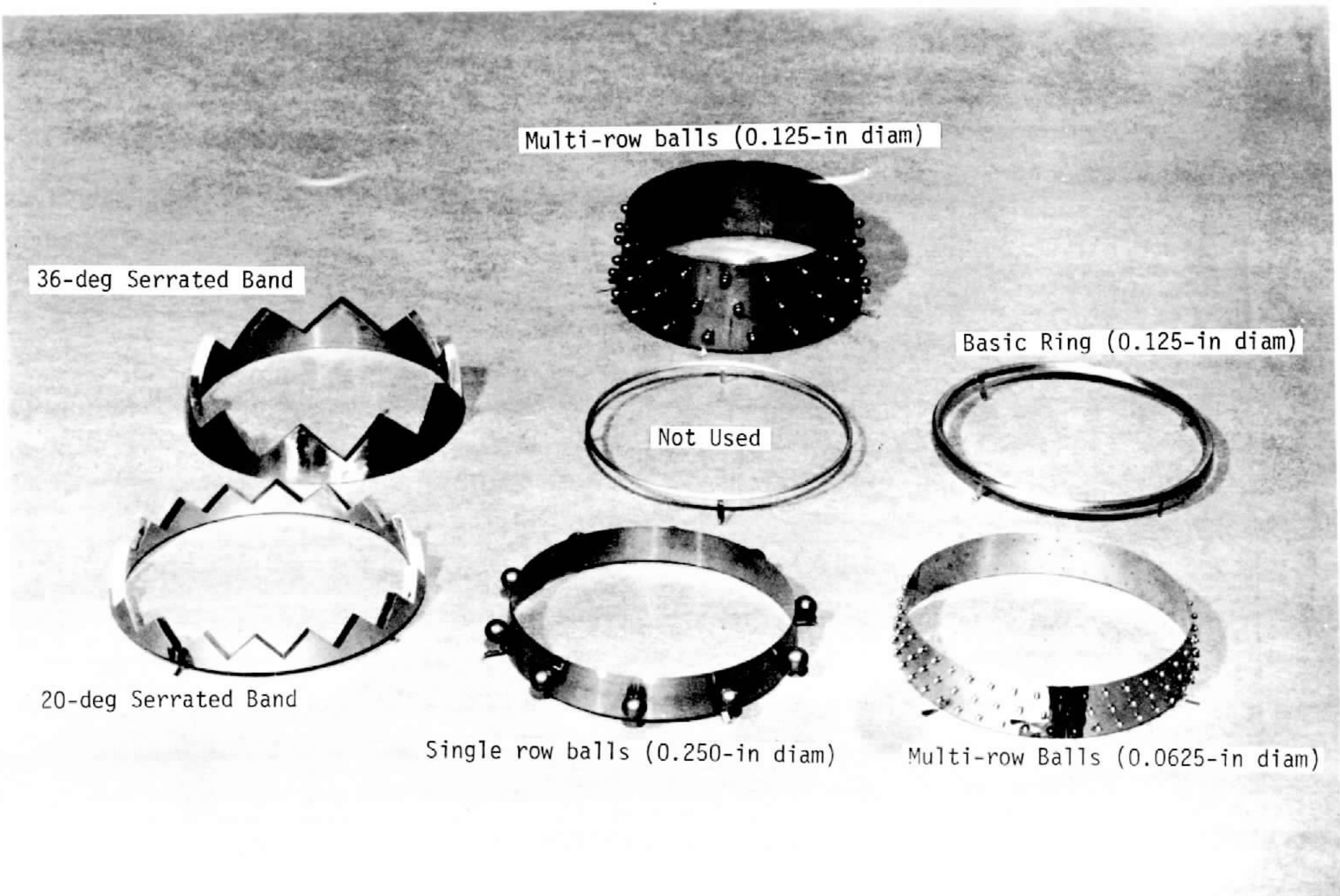
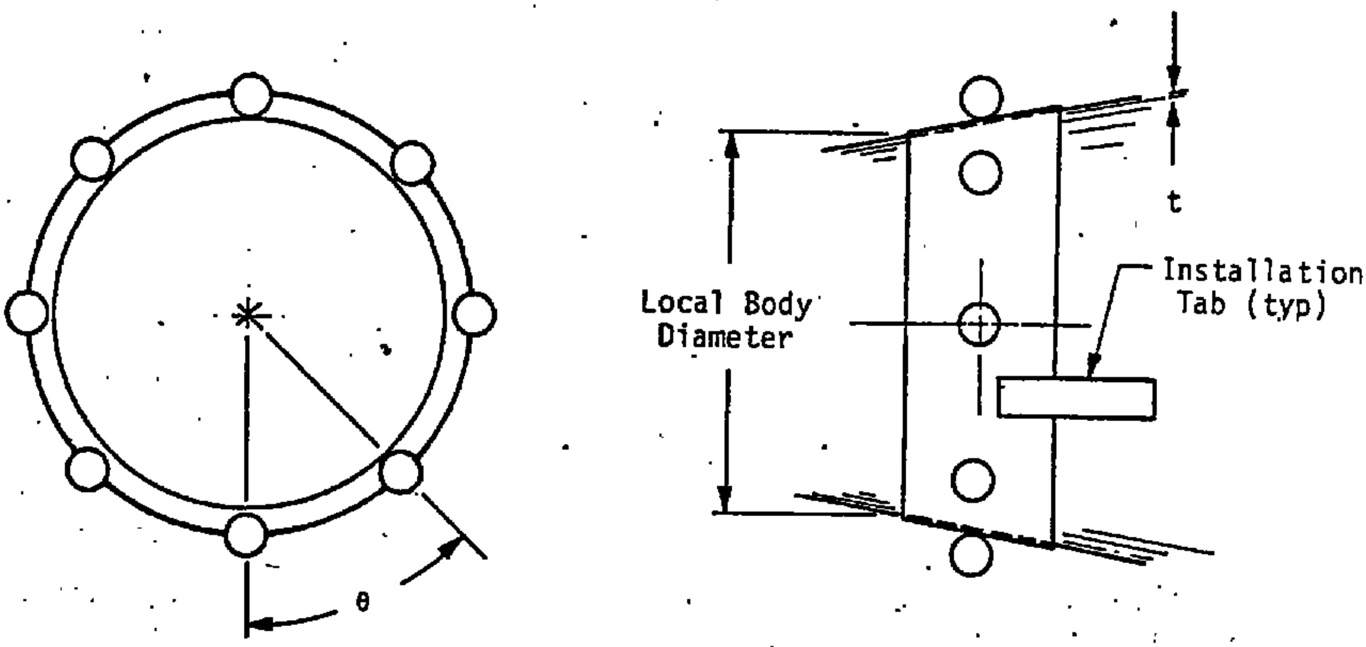
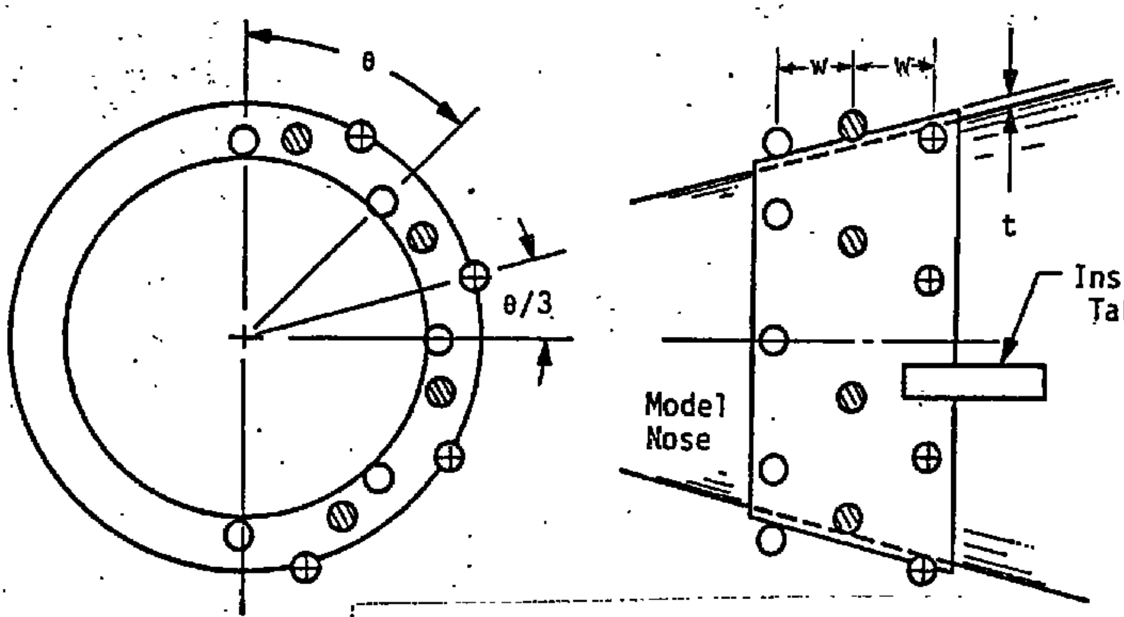


Fig. 4. Boundary Layer Trips



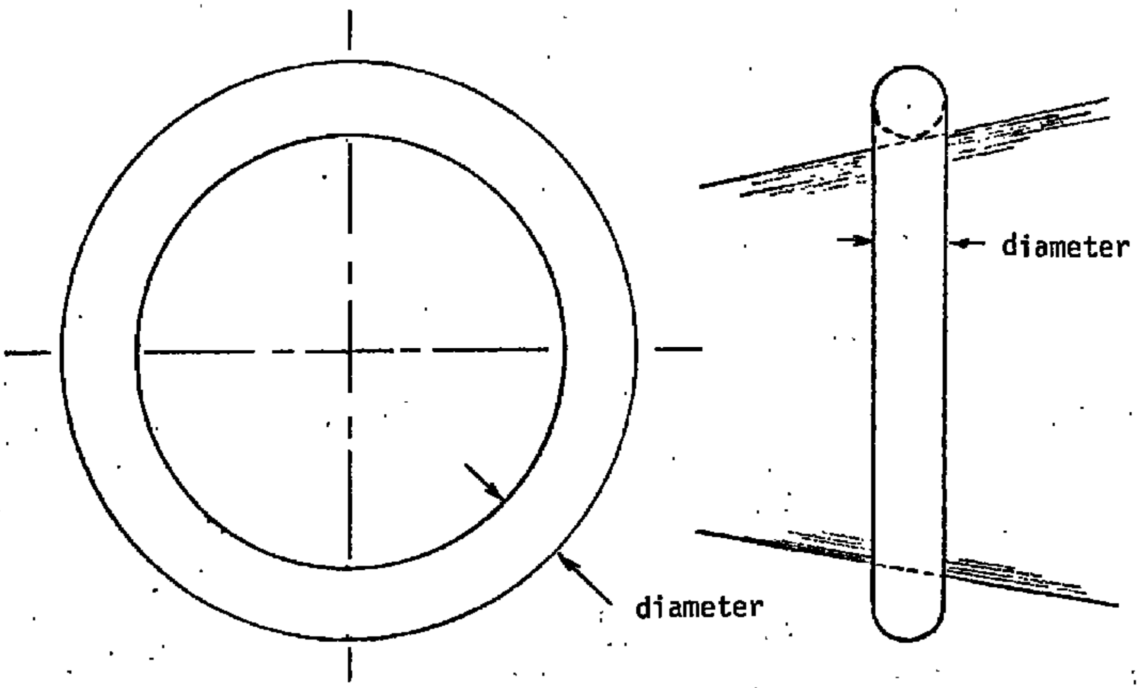
a. Spherical Ball Bearings-
Single Row Distribution



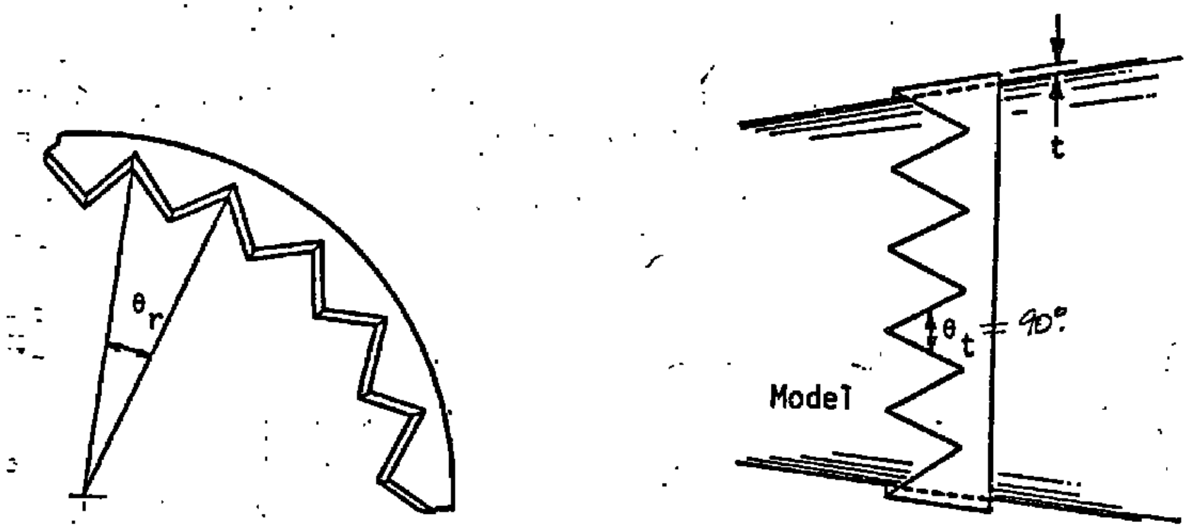
b. Spherical Ball Bearings-
Multiple Row Distribution

NOTE: All trip dimensions given in Table 3.

Fig. 5. Trip Details



c.. Basic Ring



d. Serrated Band

Note: All trip dimensions given in Table 3.

Fig. 5 Concluded

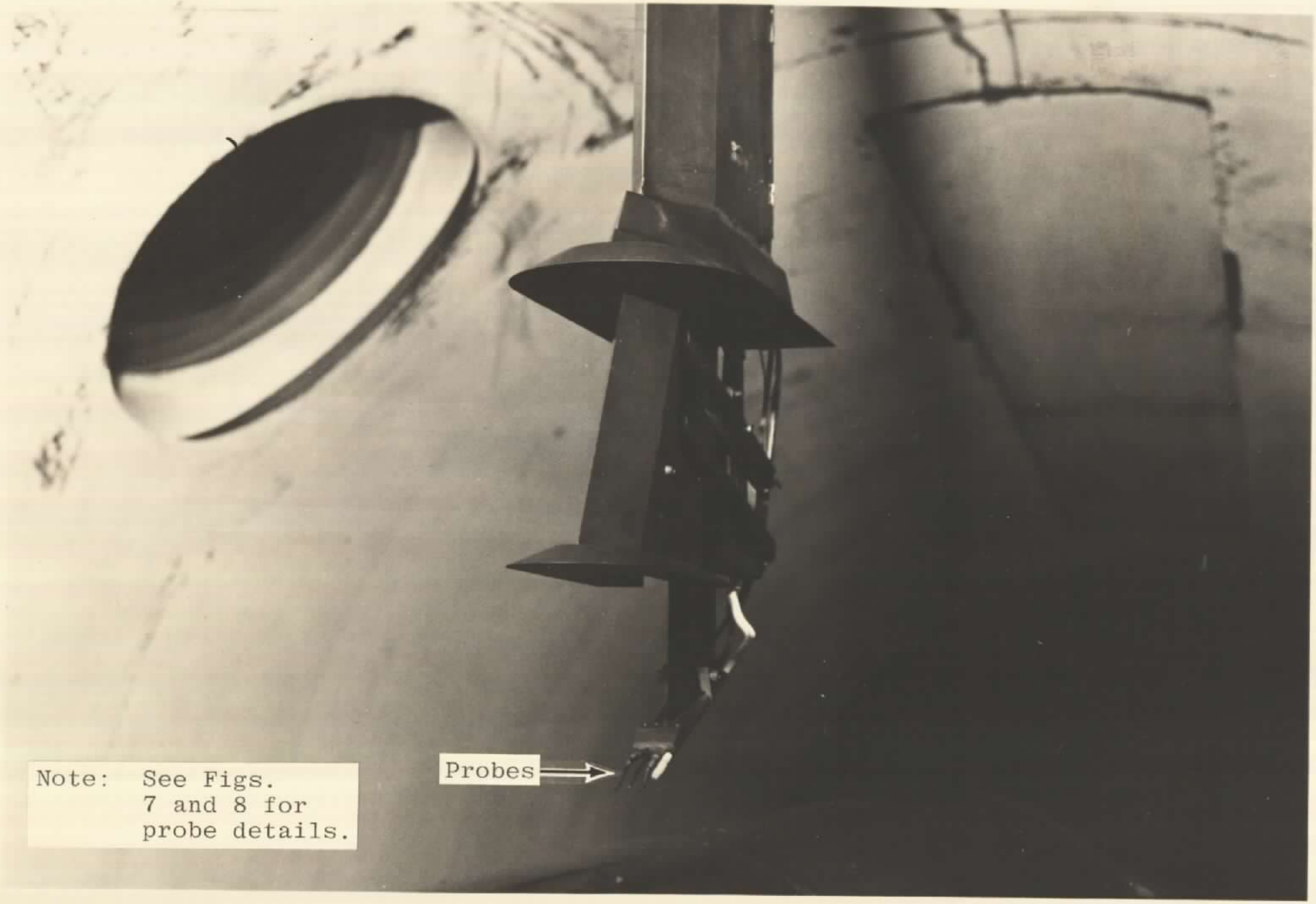
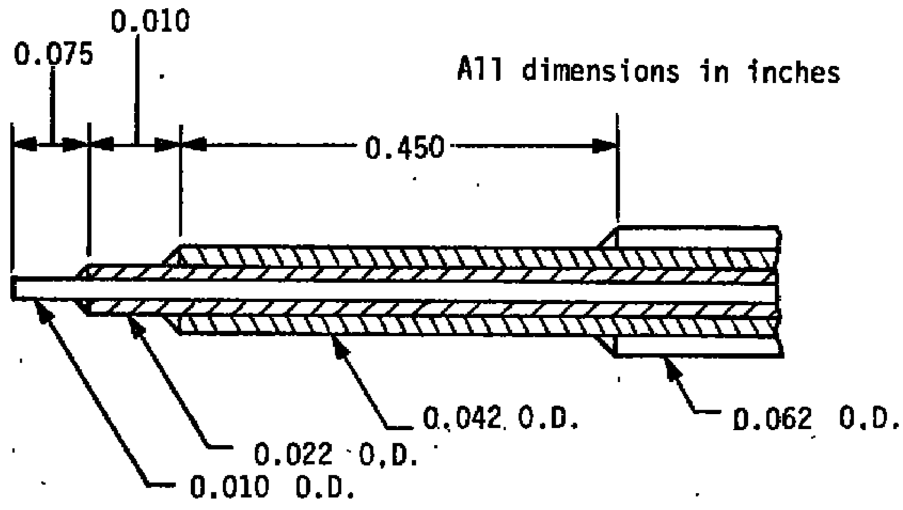
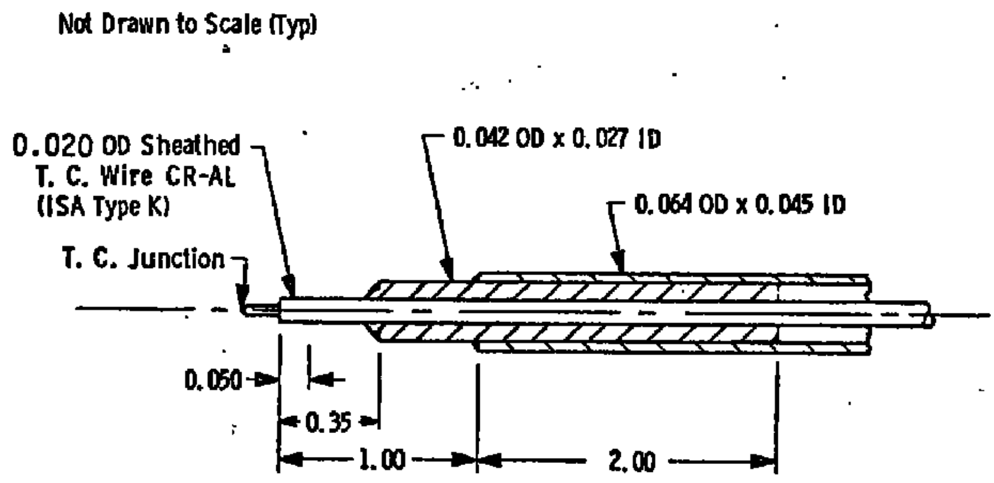


Fig. 6. X-Z Survey Mechanism

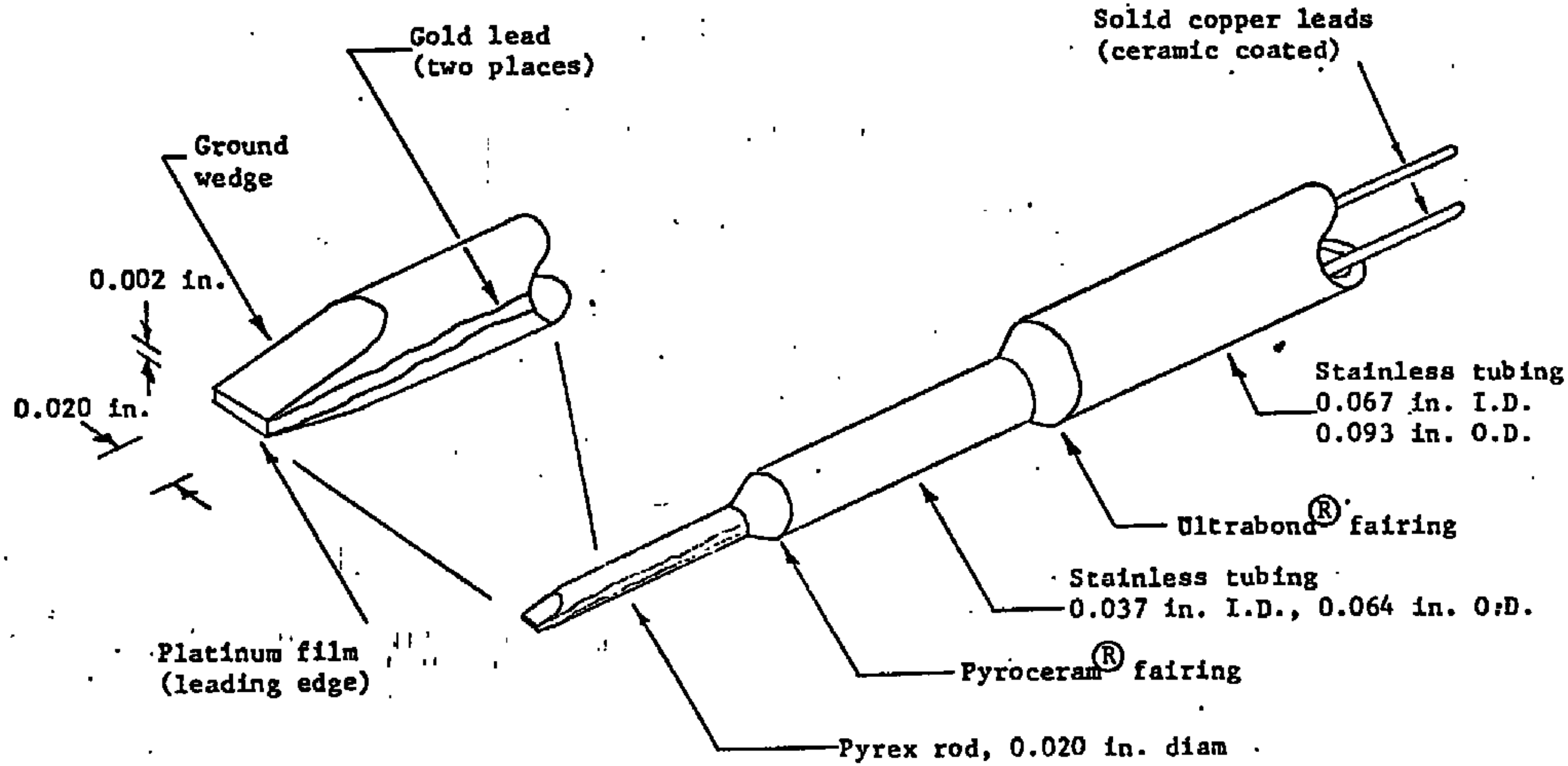


a. Pitot Pressure Probe



b. Total-Temperature Probe

Fig. 7. Probe Details



c. Hot-Film Anemomenter Probe
Fig. 7 Concluded

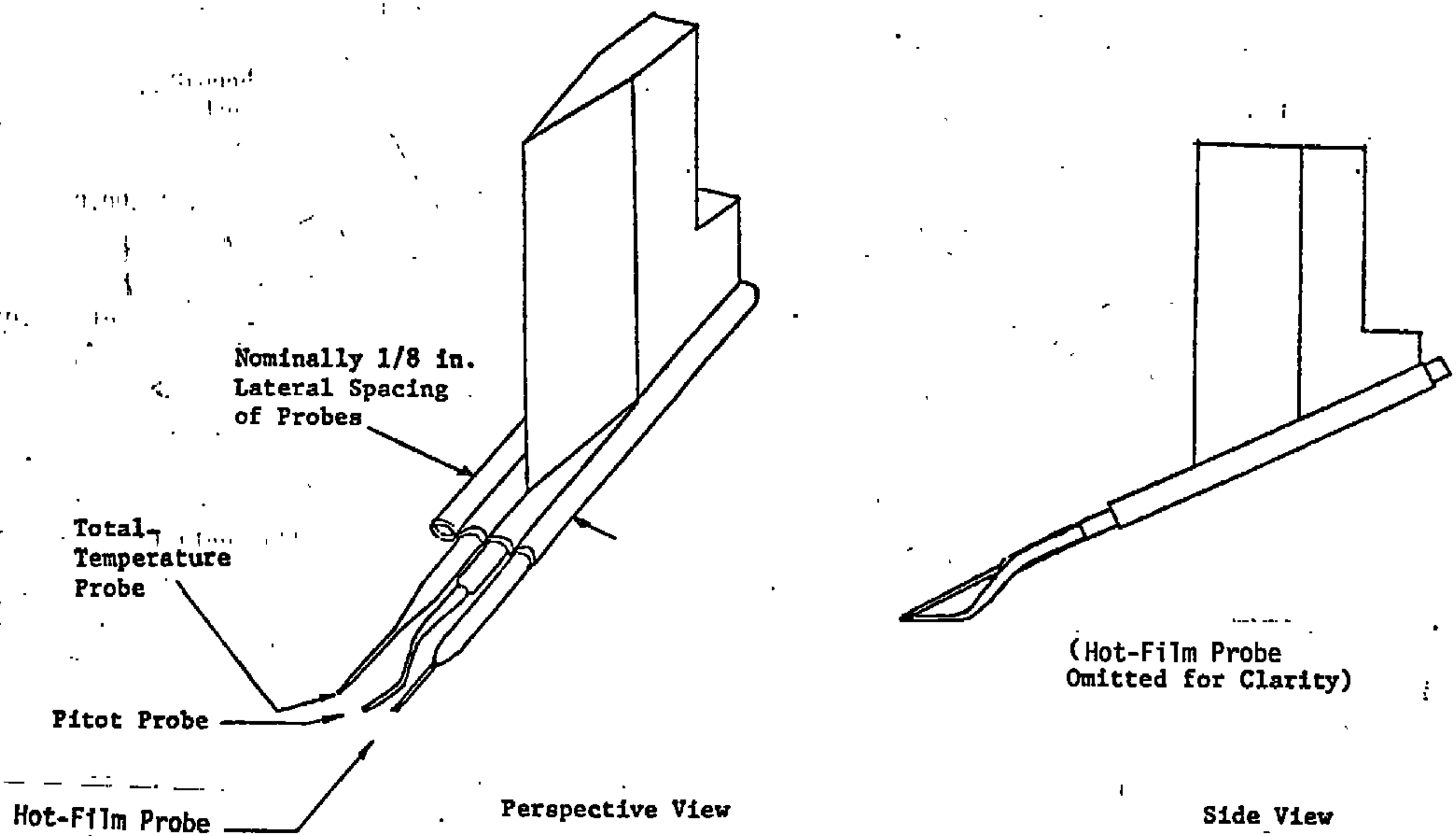


Fig. 8. Survey Probe Rake

APPENDIX II

TABLES

TABLE 1. Data Transmittal Summary

The following items were transmitted to the User/Sponsor:

	User	Sponsor
	W. T. Strike D. W. Sinclair J. C. Donaldson Calspan, MS450 AEDC/VKF/ADP Arnold AFS, TN 37389	K. L. Kushman AEDC/DOT MS900 Arnold AFS, TN 37389
Item	**No. of Copies**	**No. of Copies**
Final Tabulated Data	1	1
Final Plotted Data	1	1
Shadowgraphs	1	
Model Photographs	1	
Test Summary Report	1	1

TABLE 2. Model Instrumentation Locations

a. Pressure Taps

TAP NO.	THETA deg	X, in.	S, in. RN=0.0015
1	0	39.50	39.790
2		38.51	38.790
3		38.01	38.290
4		36.03	36.290
5		34.04	34.290
6		22.07	22.230
7		30.01	30.230
8		28.03	28.230
9		26.05	26.230
10		24.06	24.230
11		22.07	22.230
12		20.00	20.140
13		17.02	17.140
14		15.04	15.140
15		13.05	13.140
16		11.07	11.140
17		9.08	9.140
18		8.09	8.140
19	270	11.07	11.140
20	180	11.07	11.140
21	270	30.01	30.230
22	180	30.01	30.230
23	270	39.50	39.790
24	180	39.50	39.790

TABLE 2. Concluded

b. Coax Thermocouple Gages

T/C NO.	THETA deg	x, in.	S,in. RN=0.0015
1	180	38.51	38.790
2		38.01	38.290
3		37.32	37.590
4		36.03	36.290
5		35.04	35.290
6		34.04	34.290
7		33.05	33.290
8		32.00	32.230
9		31.01	31.230
10		29.72	29.930
11		29.02	29.230
12		28.02	28.230
13		27.04	27.230
14		26.03	26.230
15		25.05	25.230
16		24.05	24.230
17		23.07	23.230
19		20.99	21.140
20		20.00	20.140
21		19.01	19.140
22		18.02	18.140
23		17.02	17.140
24		16.03	16.140
25		15.04	15.140
26		14.05	14.140
27		13.05	13.140
28		12.06	12.140
29		10.77	10.840
30		10.08	10.140
31		9.08	9.140
32		8.09	8.140
101	-	18.5	37.3
102	-	25	25.2
103	-	35	35.3

NOTES:

1. Thermocouples 1-32 were coaxial surface thermocouples and thermocouples 101-103 were simply attached to inside of model surface (model wall thickness ≈ 0.25 in.).
2. Locations of thermocouples 101-103 are approximate.

TABLE 3. Trip Configuration Geometry

TRIP	θ, θ_r (deg)	Diam (k) (in)	w (in)	t (in)
Single row balls	36	0.25	-	0.008
Multiple row balls	20	0.125	0.375	0.008
Multiple row balls (0.0625)	9	0.0625	0.200	0.008
Serrated band (36 deg)	36	-	-	0.125(k)
Serrated band (20 deg)	20	-	-	0.125(k)
Ring	-	0.125	-	-

TABLE 4. Measurement Uncertainties

a. Basic Measurements

Parameter Designation	ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Precision Index (S) Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty** ±(B + t95S) Percent of Reading	Uncertainty** ±(B + t95S) Unit of Measurement	Range	Type of Measuring Device	Type of Recording Device	Method of System Calibration
Stilling Chamber Pressure, (PT), psia		0.02	30		0.26		0.30	<104	Bell and Howell Force Balance Pressure Transducer	Digital Data Acquisition System & Analog-to-Digital Converter	In-place application of multiple pressure levels measured with a pressure measuring device calibrated in the Standards Laboratory
		0.02	30	0.25		±(0.25% + 0.04)		<200			
		0.11	30		0.58		0.80	<232			
		0.11	30	0.25		±(0.25% + 0.22)		<1000			
Total Temperature (TT), °F		1	30		2		4	32 to 530	Chromel®-Alumel® Thermocouple	Doric Temperature Instrument/Digital Multiplexer	Thermocouple verification of NBS conformity/voltage substitution calibration
		1	30	0.375		±(0.375% + 2)		530 to 2300			
Pitch Angle (ALPHA SECTOR), deg		0.025	30		0		0.05	±15	Potentiometer	Digital Data Acquisition System Analog-to-Digital Converter	Heidenhain Rotary Encoder ROD700 Resolution: 0.0006 deg Overall Accuracy: 0.001 deg
Roll Angle (MODEL-ROLL), deg		0.15	30		0		0.30	±180			
DEW POINT, °F		1	30		3		5	-100 to +200	Cambridge Model 992 Hygrometer	Digital Thermometer & Digital Scanner	Panametrics MC-101 Moisture Generator
Model and Gage Temperatures:											
(TW), °F		1	30		3		5	32 to 600	Chromel®-Constantan® Thermocouples	Thermoplexer/Multiverter/RADS/DEC System 10	Thermocouple verification of NBS conformity/voltage substitution calibration
		1	30	0.5		±(0.5% + 2)		600 to 1600			
Probe Temperatures (TTTU), °F		1	30		2		4	32 to 530	Chromel®-Alumel® Thermocouple	Thermoplexer/Multiverter/RADS/DEC System 10	Thermocouple verification of NBS conformity/voltage substitution calibration
		1	30	0.375		±(0-375% + 2)		530 to 2300			

NOTES: 1. *Per definitions of Ref. 2.
2. **Uncertainty of model and probe pressures includes considerations for pressure stabilization routine (see Section 3.3.1): Precision Index and Bias are transducer values only.

TABLE 4. Continued

a. Concluded

Parameter Designation	ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Precision Index (S) Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty ±(B + $t_{95}S$) Percent of Reading	Uncertainty ±(B + $t_{95}S$) Unit of Measurement	Range	Type of Measuring Device	Type of Recording Device	Method of System Calibration
Standard Pressure System Measurements: (PW,Preston),psia		0.001			0.0025		0.0045	<2.5	ESP-32 transducers	Analog to Digital Converter/Digital Data Acquisition System	In-place application of multiple pressure levels measured with a pressure measuring device calibrated in the Standards Laboratory
Probe Pressures, psia PITOT PROBE(PP),		0.0002 0.002			0.001 0.01		0.0014 0.014	<1 <10	Druck Transducer Module mounted outside the probe housing		
Probe Position Coordinates: X		0.01	30		0		0.02		Potentiometer	Digital Data Acquisition System Analog-to-Digital Converter	Precision Inclinometer
(ZA,ZP,ZT),in.		0.001	30		0		0.002	<10			Precision Micrometer

*REFERENCE: Thompson, J. W. and Abernethy, R. B. et al. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5, February 1973

NOTES:

GC-35 (Combines GC-35 & GC-120) 1/82

TABLE 4. Concluded

b. Calculated Parameters

Parameter Designation	ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty $\pm(B + t_{95}S)$ Percent of Reading	Uncertainty $\pm(B + t_{95}S)$ Unit of Measurement	P_T
M		0.015			0.0		0.03	300
		0.01			0.0		0.02	600
P,psia	1.23			0.25		2.71		300
	0.82			0.25		1.89		600
Q,psia	0.85			0.25		1.95		300
	0.56			0.25		1.37		600
RE,ft^{-1}	0.52			0.45		1.49		300
	0.36			0.45		1.17		600
ALPHA	See ALPHA SECTOR							

*Reference: Abernethy, R. B. et al. and Thompson, J. W. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5, February 1973

TABLE 5. Test Summary

CONFIG Trip Geometry	TEST CONDITIONS PT psia	 TT deg.R	HEAT TRANSFER RUNS	MODEL SURFACE DATA (TYPE 2)	SURVEY LOCATION (DOWNSTREAM OF TRIP), DIAMETER x/k 0 MODEL STATION LOCATION, inches 12.00	 10 13.25	 10 14.50	 20 17.00	 108 25.50	 100/200 37.00	 39.00
No Trip	300	890	1008	1021	1026		1028		1025	1022	
	600	↓	1013	1014 1015	1018				1019		1020
0.250-Single	300	890	1041★ 1003 1004	1029 1030			1049† 1033 1048			1032 1047	
0.125-Mult.	↓	↓	1005	1050		1052			1051	1053	
0.125 36° Serrated			1006	1054		1056			1055		
0.125 20° Serrated			1007								
0.125 Ring											
0.0625 Mult.	↓		1011, 1040								
	410	↓	1039								

★ Trip ring rolled so that instrumentation rays were between the trip elements (18 deg)

† Survey performed between trip elements.

TABLE 5. Concluded

Total Temperature Probe Calibration Runs

1001

1002

1012

1034

1045

1046

1057

Special Runs

1009, 1010	Type 6 diagnostic runs
1042 1043, 1044	K determination runs

APPENDIX III

SAMPLE TABULATED DATA

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
AEDC BOUNDARY LAYER STABILITY TEST

DATE COMPUTED 11-OCT-83
DATE RECORDED 2-SE 3
TIME RECORDED 7:15.0
TIME COMPUTED 09:38
PROJECT NO V 8-2S

RUN NUMBER 1028 PAGE 1

SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 14.50 IN
TRIP = NO TRIP

DRUCK 2 1.854

LOOP	PT (PSIA)	TT (DEG R)	PT2 (PSIA)	P (PSIA)	ZP (IN)	PP (PSIA)	PWL (PSIA)	TWL (DEG R)	ZT (IN)	TTTU (DEG R)	ZA (IN)	TTA DEG R)	MA	LRETA
1	303.14	1350.7	2.573	0.031	0.0050	0.103	0.074	1069.2	0.0078	1102.3	0.0627	1225.3	1.34E+00	1.653E+03
2	303.02	1350.7	2.572	0.031	0.0087	0.098	0.074	1069.0	0.0115	1106.7	0.0664	1239.1	1.46E+00	1.821E+03
3	302.83	1350.7	2.570	0.031	0.0148	0.099	0.074	1069.0	0.0176	1112.8	0.0725	1263.5	1.71E+00	2.192E+03
4	302.77	1350.7	2.570	0.031	0.0192	0.095	0.074	1069.0	0.0220	1117.8	0.0769	1281.2	1.92E+00	2.553E+03
5	302.65	1350.7	2.569	0.031	0.0249	0.103	0.074	1069.0	0.0277	1124.8	0.0826	1302.5	2.23E+00	3.104E+03
6	302.47	1350.7	2.567	0.031	0.0359	0.106	0.074	1069.0	0.0387	1143.3	0.0936	1332.5	2.89E+00	4.546E+03
7	302.35	1350.7	2.566	0.031	0.0445	0.125	0.074	1069.0	0.0472	1162.4	0.1022	1346.6	3.56E+00	6.352E+03
8	302.28	1350.7	2.566	0.031	0.0494	0.137	0.074	1069.1	0.0521	1174.5	0.1071	1351.7	4.10E+00	8.101E+03
9	302.10	1350.7	2.564	0.031	0.0555	0.169	0.074	1069.1	0.0562	1191.3	0.1131	1352.6	4.78E+00	1.068E+04
10	301.92	1350.7	2.563	0.031	0.0595	0.190	0.074	1069.0	0.0622	1202.5	0.1171	1352.5	5.21E+00	1.250E+04
11	301.86	1350.7	2.562	0.031	0.0652	0.230	0.074	1069.2	0.0679	1219.2	0.1228	1351.2	5.81E+00	1.528E+04
12	302.53	1350.7	2.568	0.031	0.0713	0.297	0.074	1069.2	0.0740	1236.9	0.1289	1348.5	6.39E+00	1.836E+04
13	302.28	1350.7	2.566	0.031	0.0751	0.355	0.074	1069.3	0.0778	1247.2	0.1327	1347.3	6.60E+00	1.953E+04
14	302.41	1350.7	2.567	0.031	0.0810	0.479	0.074	1069.2	0.0837	1260.9	0.1386	1346.0	6.81E+00	2.077E+04
15	302.53	1350.7	2.568	0.031	0.0860	0.563	0.074	1069.2	0.0887	1268.4	0.1436	1345.6	6.86E+00	2.104E+04
16	302.47	1350.7	2.567	0.031	0.0906	0.721	0.074	1069.1	0.0933	1275.2	0.1482	1345.4	6.89E+00	2.125E+04
17	302.53	1350.7	2.568	0.031	0.0961	0.936	0.074	1068.9	0.0988	1278.0	0.1537	1345.3	6.89E+00	2.125E+04
18	302.59	1350.7	2.568	0.031	0.1019	1.221	0.074	1068.8	0.1046	1277.8	0.1595	1345.2	6.89E+00	2.125E+04
19	302.53	1350.7	2.568	0.031	0.1064	1.577	0.074	1069.0	0.1090	1275.0	0.1640	1345.3	6.89E+00	2.123E+04
20	302.71	1350.7	2.569	0.031	0.1184	2.752	0.074	1069.0	0.1210	1262.9	0.1760	1345.3	6.89E+00	2.121E+04
21	302.83	1350.7	2.570	0.031	0.1280	3.841	0.074	1069.1	0.1306	1253.2	0.1855	1345.4	6.86E+00	2.120E+04
22	302.83	1350.7	2.570	0.031	0.1369	4.387	0.074	1069.1	0.1395	1249.3	0.1944	1345.4	6.88E+00	2.118E+04
23	302.90	1350.7	2.571	0.031	0.1481	4.551	0.074	1069.2	0.1507	1248.4	0.2056	1345.5	6.88E+00	2.116E+04
24	302.83	1350.7	2.570	0.031	0.1575	4.553	0.074	1069.1	0.1601	1248.4	0.2150	1345.5	6.88E+00	2.115E+04
25	302.96	1350.7	2.571	0.031	0.1689	4.547	0.074	1069.0	0.1715	1248.5	0.2264	1345.5	6.88E+00	2.115E+04
26	302.90	1350.7	2.571	0.031	0.1781	4.544	0.074	1069.0	0.1807	1248.5	0.2356	1345.5	6.88E+00	2.115E+04
27	303.02	1350.7	2.572	0.031	0.1900	4.540	0.074	1069.1	0.1925	1248.6	0.2475	1345.6	6.88E+00	2.117E+04
28	303.02	1350.7	2.572	0.031	0.1988	4.537	0.074	1069.1	0.2013	1248.7	0.2563	1345.7	6.88E+00	2.119E+04
29	302.96	1350.7	2.571	0.031	0.2092	4.533	0.074	1068.9	0.2117	1248.8	0.2666	1345.9	6.89E+00	2.123E+04
30	303.02	1350.7	2.572	0.031	0.2197	4.531	0.074	1069.1	0.2222	1248.7	0.2771	1346.1	6.90E+00	2.127E+04
31	303.02	1350.7	2.572	0.031	0.2308	4.531	0.074	1069.1	0.2333	1248.7	0.2882	1346.4	6.91E+00	2.133E+04

PHI = 10.0 DEG
M = 8.00
ALPHA = 0.0
DEW = -47.

MEAN VALUES

PT = 302.7 PSIA
TT =1350.7 DEG R
PT2 = 2.569 PSIA
RE = 1.091E+05 PER IN
MU = 7.876E-08 LBF-SEC/FT2
RHO = 8.549E-04 LBM/FT3

P = 0.0310 PSIA
PWL = 0.074 PSIA
TWL = 1069.1 DEG R
V = 3879.9 FT/SEC
Q = 1.389 PSIA
T = 97.9 DEG R

Sample 1. Flow-Field Survey (Data Type 4)

RUN NUMBER 1028

ARVIN/CALSP—N FIELD SERVICES, INC.
AEDC DIVIS.
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
AEDC BOUNDARY LAYER STABILITY TEST

DATE COMPUTED 11-OCT-83
DATE RECORDED 2-S 83
TIME RECORDED 7:15.00
TIME COMPUTED 09:38
PROJECT NO V 8-26

RUN NUMBER 1028 PAGE 2

SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 14.50 IN
TRIP = NO TRIP

LOOP	ZP (IN)	PP/PPE	ML	ML/ME	TTLU (DEG R)	TTL (DEG R)	TTL/TTE	TL (DEG R)	UL (FT/SEC)	UL/UE	LRE	LRET	ERMSK
1	0.0050	0.023	7.05E-01	0.102	1094.1	1100.5	0.818	1001.0	1.093E+03	0.286	9.410E+02	8.840E+02	1.0175E+00
2	0.0087	0.022	6.48E-01	0.094	1103.4	1108.9	0.824	1022.9	1.016E+03	0.266	8.441E+02	8.005E+02	1.0095E+00
3	0.0148	0.022	6.66E-01	0.097	1109.8	1115.6	0.829	1024.8	1.045E+03	0.273	8.649E+02	8.180E+02	9.9550E-01
4	0.0192	0.021	6.11E-01	0.089	1114.6	1119.5	0.832	1041.7	9.672E+02	0.253	7.792E+02	7.433E+02	1.0060E+00
5	0.0249	0.023	7.02E-01	0.102	1121.2	1127.6	0.838	1026.6	1.102E+03	0.288	9.097E+02	8.553E+02	1.0065E+00
6	0.0359	0.023	7.33E-01	0.107	1138.0	1145.2	0.851	1034.0	1.156E+03	0.302	9.424E+02	8.815E+02	9.8201E-01
7	0.0445	0.028	8.99E-01	0.131	1156.0	1166.4	0.867	1004.1	1.397E+03	0.365	1.196E+03	1.084E+03	1.0035E+00
8	0.0494	0.030	9.85E-01	0.143	1167.6	1180.0	0.877	988.3	1.516E+03	0.397	1.335E+03	1.188E+03	9.9150E-01
9	0.0555	0.037	1.16E+00	0.168	1183.8	1200.3	0.892	947.1	1.744E+03	0.456	1.647E+03	1.409E+03	1.0015E+00
10	0.0595	0.042	1.26E+00	0.183	1194.9	1213.9	0.902	922.5	1.871E+03	0.489	1.846E+03	1.541E+03	9.9600E-01
11	0.0652	0.051	1.42E+00	0.206	1211.3	1234.5	0.918	880.4	2.063E+03	0.539	2.202E+03	1.761E+03	9.8951E-01
12	0.0713	0.066	1.65E+00	0.240	1229.3	1258.7	0.935	814.2	2.311E+03	0.604	2.815E+03	2.107E+03	9.6901E-01
13	0.0751	0.078	1.83E+00	0.266	1240.0	1274.0	0.947	762.8	2.478E+03	0.648	3.373E+03	2.394E+03	9.9400E-01
14	0.0810	0.106	2.16E+00	0.314	1255.3	1297.4	0.964	671.5	2.742E+03	0.717	4.646E+03	2.974E+03	9.8451E-01
15	0.0860	0.124	2.35E+00	0.342	1264.8	1311.6	0.975	622.0	2.879E+03	0.753	5.569E+03	3.347E+03	9.9500E-01
16	0.0906	0.159	2.69E+00	0.391	1271.3	1324.9	0.985	547.5	3.066E+03	0.802	7.542E+03	4.062E+03	9.9400E-01
17	0.0961	0.207	3.08E+00	0.448	1277.0	1337.9	0.994	462.2	3.244E+03	0.848	1.062E+04	5.013E+03	9.9750E-01
18	0.1019	0.264	3.53E+00	0.514	1278.4	1346.2	1.001	385.2	3.398E+03	0.889	1.549E+04	6.276E+03	9.8251E-01
19	0.1064	0.348	4.03E+00	0.586	1276.9	1351.2	1.004	318.4	3.523E+03	0.921	2.291E+04	7.855E+03	9.8951E-01
20	0.1184	0.607	5.35E+00	0.777	1265.6	1352.3	1.005	201.4	3.719E+03	0.973	5.883E+04	1.310E+04	9.9700E-01
21	0.1280	0.848	6.33E+00	0.920	1255.3	1348.8	1.002	149.8	3.796E+03	0.993	1.085E+05	1.801E+04	9.8151E-01
22	0.1369	0.968	6.76E+00	0.984	1250.1	1346.3	1.001	132.6	3.819E+03	0.999	1.394E+05	2.049E+04	9.7651E-01
23	0.1481	1.005	6.89E+00	1.002	1248.5	1345.4	1.000	128.1	3.824E+03	1.000	1.495E+05	2.124E+04	9.9450E-01
24	0.1575	1.005	6.89E+00	1.003	1248.4	1345.2	1.000	128.1	3.824E+03	1.000	1.496E+05	2.125E+04	9.7551E-01
25	0.1689	1.004	6.89E+00	1.002	1248.5	1345.4	1.000	128.3	3.824E+03	1.000	1.492E+05	2.122E+04	9.8301E-01
26	0.1781	1.003	6.89E+00	1.001	1248.5	1345.3	1.000	128.3	3.824E+03	1.000	1.490E+05	2.121E+04	9.8451E-01
27	0.1900	1.002	6.88E+00	1.001	1248.6	1345.4	1.000	128.4	3.824E+03	1.000	1.487E+05	2.119E+04	1.0010E+00
28	0.1988	1.001	6.88E+00	1.001	1248.7	1345.5	1.000	128.5	3.824E+03	1.000	1.485E+05	2.117E+04	9.9650E-01
29	0.2092	1.001	6.88E+00	1.000	1248.8	1345.6	1.000	128.6	3.824E+03	1.000	1.483E+05	2.116E+04	9.9450E-01
30	0.2197	1.000	6.88E+00	1.000	1248.7	1345.5	1.000	128.7	3.824E+03	1.000	1.482E+05	2.115E+04	1.0005E+00
31	0.2308	1.000	6.88E+00	1.000	1248.7	1345.5	1.000	128.7	3.824E+03	1.000	1.482E+05	2.115E+04	1.0000E+00

ERMS LAST LOOP 3.053E-02

MEAN VALUES

PHI = 10.0 DEG
M = 8.00
ALPHA= 0.0 DEG

PT = 302.7 PSIA
TT =1350.7 DEG R
P = 0.0310 PSIA
T = 97.9 DEG R

TWL/TTE = 0.7945
PWL = 0.074 PSIA
TWL =1069.1 DEG-R

EDGE VALUES

PPE = 4.531E+00 PSIA
ME = 6.876E+00
TTE = 1.346E+03 DEG R
UE = 0.382E+04 FT/SEC

Sample 1. Continued

RUN NUMBER 1028

ARVIN/CALSPA" FIELD SERVICES,INC.
AEDC DIVISI
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
AEDC BOUNDARY LAYER STABILITY TEST

DATE COMPUTED 11-OCT-83
DATE RECORDED 2-SE 3
TIME RECORDED 7:15.
TIME COMPUTED 09:38
PROJECT NO V B-25

RUN NUMBER 1028 PAGE 3

SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 14.50 IN
TRIP = NO TRIP

MODEL SURFACE MEASUREMENTS

TAP	S (IN)	THETA (DEG)	PW (PSIA)	SD PW (PSI)	PW/P
1	39.790	0	0.0435	0.0007	1.4027
2	38.790	0	0.0407	0.0005	1.3125
3	38.290	0	0.0351	0.0005	1.1319
4	36.290	0	0.0366	0.0007	1.1798
5	34.290	0	0.0331	0.0012	1.0674
6	22.070	180	0.0767	0.0003	2.4742
7	30.230	0	0.0248	0.0007	0.8005
8	28.230	0	0.0167	0.0012	0.5397
9	26.730	0	0.0118	0.0006	0.3820
10	24.230	0	0.0268	0.0025	0.8660
11	22.230	0	0.0567	0.0032	1.8300
12	20.140	0	0.1017	0.0058	3.2816
13	17.140	0	0.1023	0.0332	3.3009
14	15.140	0	0.1323	0.0338	4.2669
15	13.140	0	0.0702	0.0003	2.2639
16	11.140	0	0.0645	0.0003	2.0819
17	9.140	0	0.0681	0.0009	2.1952
18	8.140	0	0.0758	0.0003	2.4448
19	11.140	270	0.0738	0.0003	2.3806
20	11.140	180	0.0792	0.0003	2.5555
21	30.230	270	0.0763	0.0005	2.4602
22	30.230	180	0.0801	0.0003	2.5842
23	39.790	270	0.0802	0.0009	2.5855
24	39.790	180	0.0765	0.0003	2.4667
25	0.000	0	0.0817	0.0004	2.6367
26	0.000	180	0.1291	0.0020	4.1648

T/C	S (IN)	THETA (DEG)	TW (DEG R)	SD TW (DEG R)	TW/TT
1	38.790	180	1030.9	0.55	0.763
2	38.290	180	1033.5	0.52	0.765
3	37.590	180	-280241.4	15.48	-207.483
4	36.290	180	1045.6	0.63	0.774
5	35.290	180	1044.4	0.55	0.773
6	34.290	180	1045.1	0.57	0.774
7	33.290	180	1045.9	0.57	0.774
8	32.230	180	1045.9	0.58	0.774
9	31.230	180	1050.4	0.58	0.778
10	29.930	180	1044.9	0.52	0.774
11	29.230	180	822.7	9.66	0.609
12	28.230	180	1044.1	0.36	0.773
13	27.230	180	1043.4	0.25	0.772
14	26.230	180	1042.2	0.17	0.772
15	25.230	180	1042.5	0.16	0.772
16	24.230	180	1043.7	0.24	0.773
17	23.230	180	1048.8	0.35	0.777
19	21.140	180	538.8	0.10	0.399
20	20.140	180	1060.6	0.56	0.785
21	19.140	180	1060.4	0.48	0.785
22	18.140	180	540.8	0.14	0.400
23	17.140	180	1064.5	0.25	0.788
24	16.140	180	1064.4	0.20	0.788
25	15.140	180	1069.1	0.11	0.792
26	14.140	180	1066.4	0.25	0.790
27	13.140	180	1061.0	0.26	0.786
28	12.140	180	1067.8	0.33	0.791
29	10.840	180	1068.9	0.34	0.791
30	10.140	180	1069.5	0.39	0.792
31	9.140	180	1070.8	0.38	0.793
32	8.140	180	1073.9	0.32	0.795

MEAN VALUES

PHI = 10.0 DEG
M = 8.00
ALPHA = 0.0 DEG
CLD = 1.398E+01

PT = 302.7 PSIA
TT =1350.7 DEG R
P = 0.0310 PSIA

TORK = 549.8 DEG R
T = 97.9 DEG R

Sample 1. Continued

RUN NUMBER 1028

ARVIN/CALSP FIELD SERVICES, INC.
AEDC DIVISI
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
AEDC BOUNDARY LAYER STABILITY TEST

DATE COMPUTED 11-OCT-83
DATE RECORDED 2-S :3
TIME RECORDED 7:15.50
TIME COMPUTED 09:38
PROJECT NO V 6-25

RUN NUMBER 1028 PAGE 4

SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 14.50 IN
TRIP = NO TRIP

INTEGRAL EVALUATION

LOOP	ZP/DEL	PP/PPD	ML/MD	TTL/TTD	TL/TD	RHOL/RHOD	UL/UD	MUTL/MUTD	LRE/LRED	DITTL/DITTD	LRET/LRETD
1	3.788E-02	2.485E-02	1.071E-01	8.166E-01	7.232E+00	1.397E-01	2.808E-01	5.380E+00	7.575E-03	1.108E-01	4.564E-02
2	6.591E-02	2.366E-02	9.854E-02	8.228E-01	7.389E+00	1.367E-01	2.667E-01	5.458E+00	6.795E-03	1.414E-01	4.133E-02
3	1.121E-01	2.401E-02	1.012E-01	8.279E-01	7.403E+00	1.365E-01	2.741E-01	5.465E+00	6.963E-03	1.653E-01	4.223E-02
4	1.455E-01	2.296E-02	9.291E-02	8.307E-01	7.525E+00	1.343E-01	2.537E-01	5.524E+00	6.273E-03	1.791E-01	3.838E-02
5	1.886E-01	2.478E-02	1.066E-01	8.368E-01	7.416E+00	1.362E-01	2.891E-01	5.471E+00	7.323E-03	2.083E-01	4.416E-02
6	2.720E-01	2.550E-02	1.114E-01	8.498E-01	7.470E+00	1.353E-01	3.031E-01	5.497E+00	7.587E-03	2.706E-01	4.551E-02
7	3.371E-01	3.014E-02	1.367E-01	8.656E-01	7.254E+00	1.393E-01	3.604E-01	5.391E+00	9.629E-03	3.465E-01	5.598E-02
8	3.742E-01	3.318E-02	1.497E-01	8.756E-01	7.139E+00	1.415E-01	3.987E-01	5.334E+00	1.075E-02	3.946E-01	6.135E-02
9	4.205E-01	4.072E-02	1.757E-01	8.907E-01	6.842E+00	1.477E-01	4.575E-01	5.185E+00	1.326E-02	4.675E-01	7.276E-02
10	4.508E-01	4.597E-02	1.910E-01	9.008E-01	6.665E+00	1.516E-01	4.909E-01	5.093E+00	1.486E-02	5.167E-01	7.956E-02
11	4.939E-01	5.553E-02	2.155E-01	9.161E-01	6.360E+00	1.589E-01	5.411E-01	4.934E+00	1.772E-02	5.903E-01	9.092E-02
12	5.402E-01	7.171E-02	2.511E-01	9.340E-01	5.887E+00	1.718E-01	6.063E-01	4.675E+00	2.266E-02	6.773E-01	1.088E-01
13	5.689E-01	8.587E-02	2.782E-01	9.454E-01	5.511E+00	1.833E-01	6.502E-01	4.466E+00	2.716E-02	7.322E-01	1.236E-01
14	6.136E-01	1.157E-01	3.261E-01	9.628E-01	4.851E+00	2.083E-01	7.194E-01	4.076E+00	3.740E-02	8.175E-01	1.536E-01
15	6.515E-01	1.359E-01	3.578E-01	9.733E-01	4.493E+00	2.248E-01	7.551E-01	3.852E+00	4.403E-02	8.685E-01	1.728E-01
16	6.864E-01	1.741E-01	4.082E-01	9.837E-01	3.919E+00	2.576E-01	8.044E-01	3.475E+00	6.071E-02	9.176E-01	2.097E-01
17	7.280E-01	2.260E-01	4.678E-01	9.928E-01	3.339E+00	3.026E-01	8.510E-01	3.064E+00	8.548E-02	9.654E-01	2.588E-01
18	7.720E-01	2.948E-01	5.368E-01	9.990E-01	2.783E+00	3.630E-01	8.915E-01	2.639E+00	1.247E-01	9.961E-01	3.240E-01
19	8.061E-01	3.869E-01	6.121E-01	1.003E+00	2.300E+00	4.393E-01	9.242E-01	2.239E+00	1.844E-01	1.014E+00	4.056E-01
20	8.970E-01	6.645E-01	8.124E-01	1.003E+00	1.455E+00	6.944E-01	9.756E-01	1.455E+00	4.736E-01	1.018E+00	6.764E-01
21	9.697E-01	9.274E-01	9.615E-01	1.001E+00	1.082E+00	9.336E-01	9.959E-01	1.082E+00	8.739E-01	1.005E+00	9.297E-01
22	1.037E+00	1.059E+00	1.026E+00	9.990E-01	9.580E-01	1.055E+00	1.002E+00	9.580E-01	1.122E+00	9.952E-01	1.058E+00
23	1.122E+00	1.099E+00	1.047E+00	9.983E-01	9.257E-01	1.091E+00	1.003E+00	9.257E-01	1.203E+00	9.916E-01	1.097E+00
24	1.193E+00	1.100E+00	1.048E+00	9.982E-01	9.253E-01	1.092E+00	1.003E+00	9.253E-01	1.204E+00	9.916E-01	1.097E+00
25	1.280E+00	1.098E+00	1.047E+00	9.983E-01	9.266E-01	1.090E+00	1.003E+00	9.266E-01	1.201E+00	9.924E-01	1.096E+00
26	1.349E+00	1.097E+00	1.047E+00	9.983E-01	9.271E-01	1.090E+00	1.003E+00	9.271E-01	1.200E+00	9.922E-01	1.095E+00
27	1.439E+00	1.096E+00	1.046E+00	9.984E-01	9.279E-01	1.089E+00	1.003E+00	9.279E-01	1.197E+00	9.921E-01	1.094E+00
28	1.506E+00	1.095E+00	1.046E+00	9.984E-01	9.286E-01	1.088E+00	1.003E+00	9.286E-01	1.196E+00	9.925E-01	1.093E+00
29	1.585E+00	1.095E+00	1.045E+00	9.985E-01	9.293E-01	1.087E+00	1.003E+00	9.293E-01	1.194E+00	9.934E-01	1.092E+00
30	1.664E+00	1.094E+00	1.045E+00	9.984E-01	9.297E-01	1.087E+00	1.003E+00	9.297E-01	1.193E+00	9.927E-01	1.092E+00
31	1.748E+00	1.094E+00	1.045E+00	9.984E-01	9.297E-01	1.087E+00	1.003E+00	9.297E-01	1.193E+00	9.926E-01	1.092E+00

VALUES AT DELTA

PHI = 10.0 DEG
M = 8.00
ALPHA = 0.0 DEG

DEL = 1.320E-01 IN
DEL* = 1.030E-01 IN
DEL** = 4.078E-03 IN

LRED = 1.242E+05 PER IN

PPD = 4.141E+00 PSIA
MD = 6.5794E+00
TD = 1.384E+02 DEG R
TTD = 1.348E+03 DEG R
UD = 3.812E+03 FT/SEC

RHOD = 1.426E-03 LBM/FT3
RHOUD = 5.434E+00 LBM/SEC-FT2
MUTD = 1.114E-07 LBF-SEC/FT2
DITTD = 7.132E+01 BTU/LBM
LRETD = 1.937E+04 PER IN

Sample 1. Continued

RUN NUMBER 1028

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVI[illegible]
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
AEDC BOUNDARY LAYER STABILITY TEST

DATE COMPUTED 11-OCT-83
DATE RECORDED 2- -83
TIME RECORDED 7[illegible].50
TIME COMPUTED 09:38
PROJECT NO V B-28

RUN NUMBER 1028 PAGE 5

SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 14.50 IN
TRIP = NO TRIP

PRESSURE STABILIZATION STATISTICS K= 0.250E-01

LOOP	PP	PP1/PPF	PP/PPF	PPR/PP	K	TLAG	TREC
1	0.1029	1.0879	0.6486	0.0078	0.0244	79.1	15.6
2	0.0980	1.0723	0.7113	0.0143	0.2548	80.7	15.6
3	0.0994	1.0554	0.7905	0.0070	0.0198	80.2	15.6
4	0.0951	1.0507	0.8068	0.0089	0.1705	81.6	15.6
5	0.1026	1.0262	0.9013	0.0051	-0.1031	79.2	15.6
6	0.1056	1.0087	0.9275	0.0098	0.3999	78.3	15.6
7	0.1248	0.9832	1.0504	0.0035	0.0321	72.8	15.6
8	0.1374	0.9766	1.0752	0.0030	-0.0119	69.6	19.5
9	0.1686	0.9528	1.1417	0.0101	-0.0975	62.8	19.5
10	0.1904	0.9465	1.1358	0.0029	0.0257	58.8	19.5
11	0.2300	0.9354	1.1471	0.0012	0.0002	52.6	19.5
12	0.2970	0.9178	1.1681	0.0020	0.0295	44.7	19.5
13	0.3554	0.9275	1.1248	0.0021	0.0176	39.6	19.5
14	0.4741	0.9113	1.1530	0.0019	0.0282	31.8	15.6
15	0.5628	0.9276	1.1054	0.0013	0.0265	28.1	15.6
16	0.7211	0.9138	1.0950	0.0015	0.0187	23.0	15.6
17	0.9359	0.9112	1.0701	0.0009	0.0206	18.4	15.6
18	1.2210	0.9183	1.0433	0.0013	0.0186	14.6	15.6
19	1.5773	0.9335	1.0231	0.0012	0.0204	11.6	15.6
20	2.7518	0.9551	1.0008	0.0014	0.0189	6.9	19.5
21	3.8407	0.9868	0.9989	0.0009	0.0142	5.0	19.5
22	4.3467	0.9973	1.0003	0.0003	0.0157	4.4	19.5
23	4.5514	0.9993	1.0001	0.0001	0.0111	4.3	19.5
24	4.5534	1.0002	1.0001	0.0001	0.0119	4.3	19.5
25	4.5470	1.0000	1.0000	0.0001	0.0001	4.3	19.5
26	4.5440	1.0007	1.0002	0.0002	-0.0065	4.3	19.5
27	4.5399	0.9996	0.9998	0.0001	-0.0026	4.3	19.5
28	4.5367	1.0002	0.9999	0.0001	0.0119	4.3	3.9
29	4.5333	1.0002	0.9996	0.0002	0.1248	4.3	3.9
30	4.5308	1.0002	0.9997	0.0001	0.0227	4.3	3.9
31	4.5309	1.0000	0.9998	0.0001	0.0624	4.3	3.9

Sample 1. Concluded

RUN NUMBER 1028

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISI
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
AEDC/DOT BOUNDARY LAYER TRIP

DATE COMPUTED .6-OCT-83
TIME COMPUTED :145:12
DATE RECORDED .-SEP-83
TIME RECORDED 1:50:24
PROJECT NUMBER V A-28

RUN 1003
M = 8.00

ALPHA SECTOR= 0.01 DEG.
MODEL ROLL= -0.01 DEG.

CONFIGURATION
7-DEG CONE

NOSE RADIUS,IN
SHARP

TRIP
SINGLE ROW BALLS 0.25

DATA TYPE: SURFACE HEAT TRANSFER

GAGE NO	S (IN)	THETA (DEG)	QDOT BTU/FT2-SEC	TW DEG-R	H(TT) BTU/FT2-SEC-R	ST(TT)	STC(TT)
1	38.790	180.000	0.696	562.77	8.999E-04	1.114E-03	1.381E-03
2	38.290	180.000	0.596	562.15	7.693E-04	9.523E-04	1.209E-03
3	37.590	180.000	0.767	563.48	9.917E-04	1.226E-03	1.424E-03
4	36.290	180.000	0.736	565.17	9.534E-04	1.180E-03	1.286E-03
5	35.290	180.000	0.821	565.02	1.064E-03	1.316E-03	1.329E-03
6	34.290	180.000	0.698	562.63	9.013E-04	1.116E-03	1.294E-03
7	33.290	180.000	0.765	561.55	9.868E-04	1.222E-03	1.368E-03
8	32.230	180.000	0.849	559.59	1.092E-03	1.352E-03	1.325E-03
9	31.230	180.000	0.819	558.00	1.051E-03	1.301E-03	1.275E-03
10	29.930	180.000	0.820	559.27	1.055E-03	1.306E-03	1.319E-03
11	29.230	180.000	0.722	558.70	9.277E-04	1.149E-03	1.183E-03
12	28.230	180.000	0.731	558.85	9.402E-04	1.164E-03	1.152E-03
13	27.230	180.000	0.672	558.42	8.640E-04	1.070E-03	1.070E-03
14	26.730	180.000	0.647	557.85	8.306E-04	1.026E-03	9.873E-04
15	25.730	180.000	0.647	556.95	8.292E-04	1.027E-03	9.446E-04
16	24.230	180.000	0.571	555.82	7.318E-04	9.062E-04	8.337E-04
17	23.230	180.000	0.554	559.00	7.130E-04	8.828E-04	7.945E-04
20	20.140	180.000	0.504	551.64	6.423E-04	7.956E-04	8.433E-04
21	19.140	180.000	0.513	552.33	6.535E-04	8.094E-04	7.365E-04
23	17.140	180.000	0.668	551.56	8.503E-04	1.053E-03	1.072E-03
24	16.140	180.000	0.738	553.32	9.423E-04	1.167E-03	1.109E-03
25	15.140	180.000	0.976	557.96	1.253E-03	1.551E-03	1.753E-03
26	14.140	180.000	2.251	565.23	2.919E-03	3.612E-03	3.540E-03
27	13.140	180.000	3.728	569.10	4.856E-03	6.009E-03	6.129E-03
28	12.140	180.000	1.163	552.64	1.483E-03	1.837E-03	1.837E-03
29	10.840	180.000	0.436	546.99	5.517E-04	6.835E-04	6.562E-04
30	10.140	180.000	0.647	543.48	8.163E-04	1.011E-03	9.306E-04
31	9.140	180.000	0.774	541.51	9.731E-04	1.206E-03	1.073E-03
32	8.140	180.000	0.701	547.49	8.885E-04	1.101E-03	1.156E-03

RUN 1003
DEW PT. = -40.00DEG F
C.R. = 0.0 IN

PT = 294.34
TT =1336.7 DEG R
P = 3.015E-02 PSIA
RE = 1.293E+06 PER FT
MU = 7.794E-08 LBF-SEC/FT2

V = 3859.7 FT/SEC
Q = 1.351 PSIA
T = 96.9 DEGR
PT2 = 2.50 PSIA
RHO = 8.401E-04 LBM/FT3

Sample 2. Surface Heat Transfer Data

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVI: ;
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
AEDC BOUNDARY LAYER STABILITY TEST

RUN NUMBER 1014 PAGE 1

DATE COMPUTED 12-OCT-83
DATE RECORDED 2- -83
TIME RECORDED 3:4.: 2
TIME COMPUTED 08:32
PROJECT NO V B-2S

SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 0.00 IN
TRIP = NO TRIP

MODEL SURFACE MEASUREMENTS

TAP	S (IN)	THETA (DEG)	PP (PSIA)	PW/P
1	39.790	0	0.1470	2.3674
2	38.790	0	0.1526	2.4578
3	38.290	0	0.1456	2.3440
4	36.290	0	0.1476	2.3764
5	34.290	0	0.1466	2.3610
6	22.070	180	0.1614	2.5993
7	30.230	0	0.1488	2.3954
8	28.230	0	0.1508	2.4289
9	26.230	0	0.1495	2.4069
10	24.230	0	0.1560	2.5128
11	22.230	0	0.1582	2.5467
12	20.140	0	0.1475	2.3752
13	17.140	0	0.1416	2.2799
14	15.140	0	0.1492	2.4033
15	13.140	0	0.1466	2.3604
16	11.140	0	0.1454	2.3410
17	9.140	0	0.1396	2.2475
18	8.140	0	0.1516	2.4445
19	11.140	270	0.1507	2.4273
20	11.140	180	0.1623	2.6137
21	30.230	270	0.1542	2.4836
22	30.230	180	0.1598	2.5728
23	39.790	270	0.1480	2.3827
24	39.790	180	0.1546	2.4897

T/C	S (IN)	THETA (DEG)	TW (DEG R)	TW/TT
1	38.790	180	756.3	0.559
2	38.290	180	770.9	0.570
3	37.590	180	783.7	0.579
4	36.290	180	796.6	0.589
5	35.290	180	793.6	0.587
6	34.290	180	788.0	0.583
7	33.290	180	771.0	0.570
8	32.230	180	762.8	0.564
9	31.230	180	776.3	0.574
10	29.930	180	805.5	0.595
11	29.230	180	804.8	0.595
12	28.230	180	818.0	0.605
13	27.230	180	822.9	0.608
14	26.230	180	824.2	0.609
15	25.230	180	824.6	0.610
16	24.230	180	820.9	0.607
17	23.230	180	806.0	0.596
19	21.140	180	537.8	0.398
20	20.140	180	-280877.8	-207.647
21	19.140	180	744.1	0.550
22	18.140	180	538.6	0.398
23	17.140	180	725.1	0.536
24	16.140	180	716.8	0.530
25	15.140	180	-280877.8	-207.647
26	14.140	180	708.8	0.524
27	13.140	180	701.4	0.519
28	12.140	180	707.4	0.523
29	10.840	180	707.4	0.523
30	10.140	180	712.6	0.527
31	9.140	180	714.7	0.528
32	8.140	180	713.3	0.527

PP =

PHI = 0.0 DEG
M = 8.0000
ALPHA = 0.0 DEG
DEW = -51.

PT = 606.3 PSIA
TT = 1352.7 DEG R
P = 0.0621 PSIA
RE = 0.218E+06 PER IN
PT2 = 5.146 PSIA

TDRK = 553.7 DEG R

Sample 3. Model Surface Measurements (Data Type 2)

ARVIN/CALSPAN FIELD SERVICES,INC.
AEDC DIVIS
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
AEDC BOUNDARY LAYER STABILITY TEST

DATE COMPUTED 12-0C*-83
DATE RECORDED 2-[illegible] 83
TIME RECORDED 3:46. 2
TIME COMPUTED 08:32
PROJECT NO V 8-25

RUN NUMBER 1014 PAGE 2

SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 0.00 IN
TRIP = NO TRIP

MODEL SURFACE MEASUREMENTS

PRESTON TUBE NO	PPRES	RT	HT	PTP	G	TAUK	CFX
1	0.408	13.	0.159	28.55	892.8	0.7401	1.85E-03
2	0.760	15.	0.192	34.22	1302.7	1.0781	2.69E-03

Sample 3. Concluded

ARVIN/CALSPAN-FIELD SERVICES,INC.
AEDC DIVISI( )
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
AEDC BOUNDARY LAYER STABILITY TEST

DATE COMPUTED 12-OCT-83
DATE RECORDED 2-SE
TIME RECORDED 1: 5.
TIME COMPUTED 08:30
PROJECT NO V B-28

RUN NUMBER 1001 PAGE 1

SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 0.00 IN
TRIP = NO TRIP

RUN1001
DATA TYPE: 6,TOTAL TEMPERATURE CALIBRATION

POINT	M	PT(PSIA)	TT(R)	RE	PP	[illegible]	ML	TTIU	TTUT/TT	ETA	RETD**.5
1	8.00	416.02	1350.67	1.799E+06	2.1254	[illegible]	8.9438	1247.5589	0.9237	0.9177	9.011E+00
2	8.00	413.94	1350.67	1.790E+06	2.2394	[illegible]	8.8330	1248.2862	0.9242	0.9183	8.988E+00
3	8.00	400.20	1350.67	1.731E+06	2.8105	[illegible]	8.3423	1250.0524	0.9255	0.9197	8.838E+00
4	8.00	399.10	1350.67	1.726E+06	2.8339	[illegible]	8.3220	1250.2602	0.9257	0.9199	8.826E+00
5	8.00	352.25	1349.67	1.525E+06	2.7012	[illegible]	8.1819	1250.7796	0.9267	0.9210	8.295E+00
6	8.00	350.54	1349.67	1.518E+06	2.6961	[illegible]	8.1766	1251.2471	0.9271	0.9214	8.275E+00
7	8.00	302.96	1349.67	1.312E+06	2.3220	[illegible]	8.1829	1252.6840	0.9281	0.9225	7.693E+00
8	8.00	301.67	1349.67	1.306E+06	2.3253	[illegible]	8.1726	1252.7360	0.9282	0.9226	7.676E+00
9	8.00	251.89	1348.67	1.092E+06	1.9589	[illegible]	8.1566	1253.3245	0.9293	0.9238	7.017E+00
10	8.00	250.79	1348.67	1.087E+06	1.9381	[illegible]	8.1689	1253.4803	0.9294	0.9239	7.002E+00
11	8.00	202.05	1345.67	8.787E+05	1.6013	[illegible]	8.1226	1252.8224	0.9310	0.9256	6.293E+00
12	8.00	200.83	1345.67	8.734E+05	1.5695	[illegible]	8.1250	1252.8224	0.9310	0.9256	6.274E+00
13	8.00	152.09	1341.67	6.622E+05	1.1920	[illegible]	8.1425	1252.6494	0.9316	0.9262	5.462E+00
14	8.00	151.30	1343.67	6.594E+05	1.1860	[illegible]	8.1423	1252.5282	0.9322	0.9269	5.450E+00
15	8.00	101.21	1337.67	4.441E+05	0.7947	[illegible]	8.1392	1250.8143	0.9351	0.9300	4.469E+00
16	8.00	100.84	1337.67	4.425E+05	0.7775	[illegible]	8.1741	1250.7277	0.9350	0.9299	4.461E+00

Sample 4. Total Temperature Probe Calibration (Data Type 6)